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ABSTRACT

This study investigated decision behavior exhibited by elementary school aged children in a laboratory decision task. An effort was made to separate 247 children into "auditory" and "visual" subjects on the basis of their performance on two immediate memory sub-tests from the revised (1968) ITPA. Since the correlation for the Visual test did not reach the specified level of .85, the intended comparison of "auditory" vs. "visual" subjects could not be completed. Instead, a comparison was made of within Auditory Strength (on high vs. low performers') decision strategies. The prediction that High Auditory performers would make fewer errors while "learning the task" but would be more responsive to the monotony of the task and would therefore be more apt to vary their choices in the stable-state than would the Low Auditory Sequencers was only partially confirmed. Additional hypotheses were tested. Results are discussed in light of recent sensory modality literature and children's functioning in probability decision tasks. Study limitations are assessed. (Author/CJ)

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STUDY OF VISUAL AND AUDITORY SKILLS AS RELATED TO ELEMENTARY SCHOOL EDUCATION

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December, 1969

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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U.S. DEPARTMENT OF

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CHAPTER I

INTRODUCTION AND STATEMENT OF THE PROBLEM

The activities through which a child comes to apprehend the world about him are of central interest to the educator. Bringing order and meaning to the multitude of stimuli which continuously bombard one's senses is undoubtedly a complex process. Certainly, it is an endeavor in which all men are involved and in which each of us succeeds to a greater or lesser degree.

From the wide range of stimuli in the surrounds, certain stimuli are "selected" as sensory input, processed, organized, and stored for later recall. Presumably this (sensory) datum is the raw material from which our choices and decisions are made and upon which subsequent action is based. At this point in our understanding of human development and functioning, few of the desiderata of the process which links sensory input to decision-based action are known.

It is commonly held among cognitive theorists that categorization--classifying objects and events in terms of their identity or equivalence with other objects and events--is at the heart of man's commerce with his environment. Concept attainment, in which categorical distinctions are made on the basis of appropriate defining characteristics or attributes, can itself be described as a series of decisions (Bruner, 1966), decisions the making of which most certainly involves sensory input and learning of one kind or another. According to Bruner, the regularities in decision-making constitute a strategy for the acquisition, retention, and utilization of information that assures certain forms of outcome and prohibits others. Strategies, apparently, reflect the demands of the situation in which the individual finds himself and therefore can be expected to change with the consequences of behavior in the particular situation.

While decision-making and learning, through their roles in concept attainment, can be seen to play an important part in man's efforts to order the complexity of the environment, the role of sensory input is not so readily assessed. It has been suggested that the very young child exhibits initial reliance on the proximal senses of taste and touch with a gradual shift to the more distal senses of vision and audition as the child grows and matures. Regardless of the lack of empirical support for this notion in its entirety, it seems clear that individuals, in our culture at least, do come to rely heavily on the auditory and visual modalities for purposes of classifying the phenomenal array of objects and events in their world.

According to the Tolmanian conception of learning, as experience accumulates in processing information through one or another sense modality, expectancies develop regarding the nature and occurrence of objects and events. That is, anticipatory error associated with processing information attained via the given modality decreases as experience through that modality increases. Concomitantly, the child learns that his categorizing decisions have certain consequences which he also

comes to expect and which in turn affect his learning. As he learns to expect these consequences he adjusts his behavior to fit his expectations. Through time he learns the value of correct anticipation regarding his sensory experience not only in terms of survival and the relative freedom from discomfort it provides, but also in terms of the payoff in our culture associated with being "right". Socializing agents "pour on the reinforcement coal" in relation to "correct" and "incorrect" responses. The fact that what one socializing agent regards as a correct response may, or may not, be regarded as a correct response by another, points up the complex nature of "correct" anticipation and the likelihood of variability of response potential from situation to situation.

Since in nature the usual state of affairs does not permit classification on the basis of absolute certainty, much of the learning that is involved in man's attempts to apprehend his world demands that he assume a probabilistic approach to categorization. That is, since we live in a probabilistically constrained world wherein few events are associated with probability 1.0, learning to anticipate outcomes, or the relationship between antecedents and consequents, is essentially a probabilistic matter. Even if it were not the case that the world is probabilistically constrained, it is doubtful that man could or would accurately take into account the number and nature of the relevant antecedents associated with a particular event; so that on any one occasion, learning becomes a matter of sampling the "available" stimuli, and across situations, a matter of situation sampling. In either case, this conception of learning is consistent with that set forth in the branch of mathematical learning theory which is based on the assumption that learning on any one trial is described by a simple linear transformation of the response probabilities. Explanation of learning according to these models is a matter of accounting for the learning process over a period of time as the result of simple effects of variables operating on single trials (Estes, in Marx, 1965). In the Estes stimulus sampling model (Estes, in Koch, 1959) learning is represented by changes in the connections between response classes and stimulus elements; and, learning can occur only with respect to elements sampled on any given trial. The stimulating situation amounts to a set of stimulus elements, and effective stimulation on any one trial is represented by a randomly drawn subset of elements. All stimulus elements, it is assumed, are equally likely to be sampled, and the probability of a response at any one time is equal to the proportion of elements in the stimulus set that are connected to it. On any acquisition trial all stimulus elements sampled by the organism become connected to the response reinforced on that trial. Accordingly, response probabilities would be expected to change as learning proceeds, and to eventually stabilize at some asymptotic level.

In highly developed cultures such as our own, where much of expectation of learning of sign-significance is verbally mediated, correct prediction related to auditory and visual events takes on special significance; and in education, both formal and informal, training in auditory and visual skills receives additional attention--perhaps even to the neglect of the other modalities. That is, since we tend to verbalize in vocal or written form much, if not most, of the information we attain about the world regardless of the particular sense through which it was

attained, it is expected that as a matter of course the auditory and visual senses might receive more exercise--be more highly trained--than the other senses. Achieving skill in "the three R's" of traditional education all but completely rests on the receiving, interpreting, storing and retrieving of auditory and/or visual material.

According to Gray and Wise (1959) the auditory and visual senses receive greater emphasis than the more proximal senses for very concrete reasons. Not only do they lend themselves to distance reception and consequently to stimulation of large numbers of individuals simultaneously, they are also susceptible to technologic transmission which allows for a semi-permanence in their effect--the sort achieved through recording tapes, the written word, and the like. In addition, the fine versus gross distinctions possible in transmission and reception for these modalities in all likelihood contribute ease of anticipation and retention of auditory and visual events. For these reasons alone it would appear that investigating the relationship of these two modalities to the decision process may hold some significance for the field of education.

Indidentally, it is interesting to note that in a study of preferences in cue-utilization, E. D. Adrian (1947), using a cortical mapping technique subsequent to stimulating different receptors, found that cortical specialization for the integration of sensory cues of the different senses varies from species to species. Man, apparently, has a relatively high proportion of cortical cells given over to the integration of visual and auditory cues, dogs to olfactory, and pigs to tactile.

One interpretation of these findings is that man may rely more heavily on the auditory and visual senses in coming to apprehend his world. Does he rely equally on both? Do individual humans differ in regarding to relying on one as opposed to the other? If, in fact, they do differ, then is this a difference that makes a difference? That is, does the subject who is more efficient, say in processing information via a particular modality, make qualitatively or quantitatively different predictions and decisions when confronted with situations that do not allow him to process information (categorize) via his modality of "strength"? Is the fact that an individual makes fewer errors in recalling a series of auditory cues in a simple sequencing task associated with relatively superior performance in an independent auditory prediction-decision task as compared to his performance in a similar visual task? Are higher cognitive processes such as prediction and choice differentially associated with auditory and visual functioning in the same individual; or, are such cognitive processes channel-free? These questions remain unanswered.

The present study was designed to test some of these notions directly. The primary aim was to determine whether or not children who perform differentially on an independent set of auditory and visual sequencing tasks also perform differentially in simple auditory and visual decision situations. The crucial question was this: Is there an effect of sense modality functioning that is detectable and significant in the higher cognitive processes of prediction and decision? In an effort to answer

this question, it was intended that the choice behavior of elementary school children in a two-choice, uncertain-outcome situation involving auditory and visual events be investigated.

To isolate and identify the role of sense modality functioning is not a simple matter. A review of the literature failed to reveal a single study directly concerned with this issue. Traditionally, human learning and decision behavior have been studied independently in the repetitive choice situation and without regard to the expected subjective value of the outcomes of a subject's choices to that subject. Sydney Siegel (1964) has extended the Estes probability model of learning to a decision-making theory of learning model in which an individual's choice on any given trial of a series of trials in a repetitive choice situation is regarded as the result of the degree of belief (subjective probability) that a given event will occur plus the result of the utility (subjective value) associated with the event's expected payoff. That is, the basic theoretical hypothesis of the model is that on any given trial the individual will choose "as if" he is attempting to maximize his subjectively expected utility. The Siegel model was used in the present study because of its appropriateness for investigating the relationship between sensory functioning and decision behavior.

Assuming that imposing meaning on the sensory stuff of the world can be conceived of as a series of decisions which directly involve probability learning, plus the fact that much of our learning is verbally mediated, suggested that certain psycholinguistic abilities that require the ability to reproduce a sequence of sensory stimuli may be associated in some important sense with sensory performance as well as with categorization decisions. Individuals concerned with the area of educating and treating exceptional children have long been interested in learning in relation to sensory functioning; and the role of psycholinguistic abilities looms large in the literature pertaining to the training of children with learning disabilities.

In 1961 James J. McCarthy and Samuel A. Kirk developed the Illinois Test of Phycholinguistic Abilities (ITPA). This test is a test of differential language abilities which measures nine specific language functions as well as yielding a total language age score. The abilities measured involve two levels (representational and integrative), four "channels" (auditory, vocal, visual, and motor), and five processes (decoding, association, encoding, automatic, and sequential) of language functioning. The ITPA manual (McCarthy and Kirk, 1961) states that tests at the representational level tend to involve higher mental processes, while tests at the integrative level involve fairly basic processes.

The ITPA is based on a psychological theory of language acquisition and use, developed by C. R. Osgood as an extension of Clark Hull's learning theory. The test was standardized in 1960 on 700 children between the ages of 2 and 9 years. The sample was selected from school age children and their siblings in Decatur, Illinois. The Decatur group was chosen because of its close approximation to the social class distribution of the state of Illinois. The standardization sample includes children whose I.Q., according to the 1937 revision of the Stanford Binet, was

between 80 and 120.

Children who were seriously sensorally or physically handicapped, children of the Negroid race and children from parochial schools were excluded from the sample. The same number of male and female subjects were included. Finally, children in whose homes a language other than English was regularly spoken were excluded. A complete discussion of the construction, standardization, and characteristics of the ITPA is available in McCarthy and Kirk, 1963 (90 pages).

Following the standardization of the Illinois Test of Psycholinguistic Abilities (McCarthy and Kirk, 1961) a rash of experiments appeared in the literature relating sensory input (training in a given sensory modality) to improving psycholinguistic abilities in general (Kass, 1962; Sutton, 1963; Hersch, 1964; Bateman, 1965; Meuller, 1964; Mauller and Smith, 1964; McCarthy, 1964; Smith, 1962; Kirk and Bateman, 1962). In 1968 the test was revised by Kirk, McCarthy and Kirk.

In the present study two of the revised ITPA sub-tests were used in an effort to identify subjects who performed differentially with regard to a specific set of auditory and visual stimuli--Sub-test #10 (Auditory Sequential), which is judged by the authors to assess immediate auditory memory and Sub-test #11 (Visual Sequential), judged to assess immediate visual memory. The overall stability reliability and empirical validity originally established for these two sub-tests indicated that it would be appropriate to use them for the purposes of this study. Information on the characteristics of the revised test's standardization sample and on the reliability of the revised form can be found in a 1969 manual (Paraskevopoulos and Kirk, 1969). Since the information available from the revision, on the reliability of the two subtests, led to the same conclusion with regard to their appropriateness for this study, it was decided that the tests from the revised edition would be used. It was essential, however, to establish stability coefficients for the age group under consideration before proceeding with the study proper.

Bateman (1965), using these two tests as measures of automatic sequential language abilities, separated a sample of first graders into visual and auditory learners on the basis of the discrepancy between their auditory and visual scores. If a child's auditory memory language age score exceeded his visual memory score by nine months or more, he was labelled an auditory learner; if the excess was less than nine months, he was labelled a visual learner.

Whether Bateman's separation of auditory and visual learners is a reliable and valid one is difficult to say since she presents no data on which this judgment could be made. The point of interest regarding Bateman's study, however, was this: assuming subjects could be reliably separated, do those identified as auditory subjects in terms of their ability to perform on the ITPA sub-tests differ in their decision-making strategies from those identified as visual subjects? Within the Siegel framework it seemed reasonable to ask: Given a Group of "auditory" (or "visual") subjects, does the situation factor of presentation of stimuli to one or another sensory channel have associated positive or negative

utility for a given subject as reflected in his stable-state (asymptotic) strategy?

Certain literature to be described below, leads one to expect that children do differ in their auditory and visual skills in processing information and that deficits in learning via one or another modality is susceptible to change. The literature is contradictory with regard to whether or not there is interaction between a child's auditory and visual learning ability and auditory versus visual modes of training. However, at least some studies claim superiority for auditory processing regardless of the child's pattern of strengths and deficits in learning via one or the other modality.

In a study done by Hasterock (1964) regarding the ability of mentally retarded children to overcome learning disabilities in either the auditory or visual sensory modality, as identified by scores on the ITPA, it was concluded that at least for paired associates tasks the sense modality to which the material is presented makes a difference. Learning by an auditory method for children of low auditory ability took over twice as long to reach a proficiency criterion as did learning by a visual method. For the children of low visual ability subjects made <u>initial</u> large gains under both methods. For the visually poor group training by the auditory method did not show a clear superiority. After additional training, auditory learning performance turned out to be superior and the subjects showed a "good" set toward auditory sense modality learning.

Kass (1962) and Raymond (1955, cited in Hersch, 1964), found deficit in sequential visual memory for forms correlated with reading disability in normal children. Goins (1958), on the other hand, found no correlation between the two, and in addition tachistoscopic training of visual memory for forms did not improve reading achievement. Harris (1961), Gardner (1965), and Fernald (1943) report visual memory to be improved by kinesthetic methods of one sort or another, whereas Hersch (1964) found that a kinesthetic method of teaching reading had a positive effect on sequential visualizing ability only when the nature of the stimulus or response was shared by test and training procedure.

Bateman (1965) found the auditory method of training first graders to read to be superior regardless of the modality pattern used by the child. Her findings are in agreement with others (Bleismer and Yarborough, 1965; Harris, 1965) who found no interaction between subject strength and deficit and method of training. Bleismer and Yarborough also report superiority of an auditory method to that of visual for purposes of teaching reading.

The studies of Bateman and of Bleismer and Yarborough discussed above suggest that certain cognitive processes are not channel-free processes and that information received through the auditory modality is attained, stored and transformed for later recall in such a manner as to somehow produce more efficient or "greater" learning than is achieved when similar information is received through the visual channel. The present study was designed to investigate the channel relatedness of decision-making in a probability learning situation. It was intended that auditory versus visual assets and deficits be established, in a

sample of elementary school age children on the basis of the Visual and Auditory Sequential tests of the ITPA, and Siegel's model of utility and choice be used to determine stable-state strategies in a repetitive choice situation involving the presentation of stimuli to the auditory and visual modalities separately.

The Siegel model was regarded as the most appropriate model for this study since not only is it applicable to any repetitive choice situation but it predicts pre-asymptotic and asymptotic behavior for individuals on the basis of utility-relevant factors present in the given situation. While Siegel admits that many utilities may obtain in any situation, his model focuses on two major ones, namely: the utility of a correct choice and the utility of variability. The former amounts to the satisfaction one derives from being correct plus that from any consequences which follow from being correct, such as some contingent payoff; the latter is the satisfaction derived from varying one's choices between the available alternatives and is regarded by Siegel as the negative utility of boredom. The utility of variability is of particular importance in a choice situation which is monotonous for the subject.

In the model, the over-all utility of a given situation which is expected to derive from adopting a particular strategy S is assumed to be the sum of the expected utility of a correct choice and the expected utility of variability: E (Us) = E (Uc) + (Uv)

It follows from the model that the total expected utility of a strategy E (Us) can be modified experimentally by manipulating the consequences of being correct by attaching additional utility to the choices through monetary payoff, say, contingent upon correct responses. Siegel (1964) has shown that stable-state strategies more nearly approximate a pure strategy--choice of the more frequently occurring event on all trials--under "payoff" conditions (e.g., 5¢ for a correct response), "payoff loss" conditions (e.g., subject receives 5¢ for each correct prediction and loses 5¢ for each incorrect prediction) than is the case under a "no payoff" condition. Similarly E (Us) can be modified by manipulating factors associated with the utility of variability. One such factor is monotony. Presumably in a situation which is monotonous the tendency to vary one's responses as a way of enriching (reducing boredom in) the task or situation would also be high. Reduction of monotony and consequently reduction of the tendency to vary one's choices can also be achieved through providing cognitive enrichment in the stimulus situation, for example, by adding to the number of alternatives from among which the subject must choose on any one trial, or by varying the number of events that occur in conjunction, and so on. Enriching the kinesthetic nature of the response, for example allowing the subject to move from one position to another in order to register his prediction, would presumably have the same effect.

In other words, the total expected utility of a strategy can be modified by adding extrinsic payoff, or through introducing cognitive and/or kinesthetic enrichment of the stimulus or response aspects of the situation. It can be argued that the effect of such manipulation is to increase the degree of involvement or investment of the subject in the

task at hand.

The elaboration of the formula for calculating total expected utility of a strategy:

$$E(Us) = E(Uc) + E(Uv) = \sum_{i=1}^{k} a_i P_i \pi_i + b \sum_{i=1}^{k} P_i (1 - P_i)$$

where k = number of alternatives

π_i = probability that choice of the i^{th} alternative will be correct, where i = 1, 2, . . . k

a_i = marginal utility of correct choice of the i^{th} Alternative

b = marginal utility of choice variability

P_i = stable-state probability that subject chooses i^{th} Alternative

implies that for a given stable state, P_i value, any procedure which reduces the marginal utility of a correct choice a_i (all else being equal) increases the marginal utility of variability b. Therefore, if a_i is held constant experimentally, any decrease in b should be reflected in a higher stable-state strategy. It should be carefully noted that, theoretically, "low b" situations are those in which the utility of variability of the situation is low, despite trial to trial variability.

Suppose now, that we place an auditory subject in a situation in which he is required to predict over a series of 200 trials, which of two tones will sound on each trial. The only information given to the subject is that one and only one of the two events (E_1--low tone or E_2--high tone) will occur on any one trial. In fact, which event occurs is randomly determined and is therefore not dependent on the choice the subject makes. Say that the experimenter has set the occurrence of events π_i at: E_1 occurs on 75% of the trials and E_2 occurs on 25% of the trials in every block of 20 trials; $\pi_1 = .75$, $\pi_2 = .25$.

In a repetitive choice situation of this sort the subject typically begins by alternating his choices between the two alternatives. As the "game" progresses he shifts his choice in light of the feedback he receives regarding the actual occurrence of events. Presumably the subject entertains various hypotheses about the proportions in which the events acutally occur. He must detect, store, and recall the information necessary to maximize his winnings (satisfaction) in the given situation. Over a period involving numerous trials he checks out (his) various hypotheses and eliminates all but one hypothesis, namely: low tone comes on in most of the trials. He may even conclude "the proportions in which the events occur is roughly low tone 75% of the time and high tone 25% of the time".

Since the occurrence of an event on any one trial is random the subject may (is likely to) conclude that in order to maximize his winnings he must choose the low tone on every trial. Subsequently he predicts "low, low, low, etc".

It can be assumed that, as the trials accumulate, the likelihood is high that the situation will become boring to him and conceivably he may ask himself whether or not on any one trial he might "be lucky enough" to out-guess the random machine and accurately predict the less frequent event, thereby achieving satisfactory as well as relieving the boredom. That is while the over-all utility of being correct is high, the marginal utility of a correct response (average utility associated with being correct on any one trial) may be small. One might expect, therefore, that the subject may derive satisfaction from varying his responses now and then. Since he has learned that the events actually occur in approximately a 75:25 split, it is assumed that the expected satisfaction (payoff) based on having learned the proportions of occurrences will place a ceiling on the number of times he will vary (attempt to predict the less frequent event) his responses. In other words, in light of the information he possesses he would not drop below a matching strategy of predicting the more frequent event in the actual proportion (.75) in which it occurs. If the assumptions so far are correct, an appropriate prediction would be that the auditory subject in an auditory situation, as a function of becoming bored in an experiment that involves many trials and no opportunity to introduce cognitive complexity or kinesthetic complexity into the situation except through choice of alternatives, will in fact, vary his choices and not choose the more frequent event on all occasions. This is another way of saying that the auditory subject will stabilize at something greater than a matching strategy and something less than a pure strategy--he will not choose the more frequently occurring event on all trials but he will choose it on at least 75% of the trials in this monotonous auditory situation.

Supposing, however, that the auditory subject is asked to perform in a visual situation in which he is required to predict which of two visual events will occur on any one of a series of 200 trials, under the same π_1 and "no payoff" conditions as were specified in the auditory situation. How might he perform now? Certainly it is expected that he would start out alternating his responses as before since he has no knowledge of how frequently the two events occur or which is the more frequent, nor consequently how he might maximize his winnings or overall satisfaction. We would assume that since he is an auditory subject in a situation requiring him to process, store and retrieve information of a visual nature, he is very apt to be less adept--he is apt to make more faulty predictions and take, at least somewhat, longer to learn in which proportions the two events actually occur. On this basis, that is if our assumptions are true, the visual situation is likely to be regarded as a more challenging (cognitively complex) situation than was the auditory situation--the monotony of the task will "make itself felt" much later, if at all, and boredom will be minimized. Certainly the task is not so complex as to prohibit the subject from reaching the point at which he will hypothesize "to maximize winnings one must select the more frequently occurring event E_1 on all trials". On the other hand, it seemed reasonable to assume that he would make more errors in the process of learning the event probabilities, he would therefore, stabilize his choices later in the series; but he would, not being as bored or being more challenged, more nearly approximate a pure strategy in his stable-state choices than he did in the auditory situation.

Similarly, we would predict that the visual subject would more nearly approximate a pure strategy in his stable-state choices in an auditory situation than he would in the visual situation. It should be noted that one of the major assumptions on which these particular predictions for both auditory and visual subjects rested was that the subjective satisfaction with being "correct" is a factor which is constant for the two modalities. That such an assumption may not be tenable was necessarily borne in mind when the empirical findings were interpreted. Further, there are certain obvious problems associated with identifying visual and auditory subjects by means of measures reflecting mainly a memory factor. Undoubtedly, more than storing and recall is involved in processing information via any sensory channel. Any correspondence or lack of same between the predicated and the observed results were interpreted in the light of this limitation.

Purpose of the Study

The express purpose of the present study was to examine the relationship between sensory functioning of the auditory and visual modalities and strategy behavior in a simple, controlled laboratory decision situation. An effort was made to separate children age seven years through eight years three months into "auditory" and "visual" subjects on the basis of their performance on two subtests of the Illinois Test of Psycholinguistic Abilities and to determine whether or not these two groups adopt different stable-state strategies in visual vs. auditory decision tasks. A secondary aim of the study was to examine the relative stability of the ITPA measures for the two modalities and to determine whether or not the decision performance of the auditory and visual subjects shifts under appropriate reinforcement conditions.

Siegel's mathematical model of utility theory was used to generate the hypotheses and interpret the results. It was expected that the data from the study would incidentally provide a substantial test of the quantitative validity of the model with regard to the utility of variability parameter. Conclusions of the study were established on the basis of results for both learning and stable-state, or asymptotic, aspects of the tasks.

Objectives of the Study

The objectives of the study were the following:

1. To determine whether or not children are reliably separable as visual or auditory subjects.
2. To determine whether or not children identified as auditory or visual subjects on an independent measure exhibit significantly different decision strategies (which will incidentally serve as a validation of the two ITPA subtests as an instrument useful for the purpose of identifying auditory and visual modality strength).
3. To determine the degree of stability of the modality 'type', or of the superior performance modality, under conditions of meaningful payoff (monetary reward) for correct performance in the less "strong" modality.
4. To test the quantitative validity of the model with regard to the utility of variability parameter under different monotony conditions.

In order to implement the above objectives the following specific hypotheses were to be tested:

I. In the repetitive choice situation auditory and visual subjects more nearly approximate a pure stable-state strategy in a decision situation which requires processing information via their weaker modality than in a decision situation which requires information processing via their modality of strength.

II. In the repetitive choice situation auditory and visual subjects experience greater series unexpectedness in the pre-asymptotic aspect of a decision task which involves stimulus input via the weaker modality; that is, prior to reaching an asymptote the subjects will accurately anticipate the events on a greater proportion of the trials in the decision task which involves input via the modality of strength and will therefore arrive at their asymptotic level earlier in the series.

III. In the repetitive choice situation auditory and visual subjects in their pre-asymptotic performance under conditions of risk (payoff-loss) in a decision task involving the weaker modality, will perform in such a way as to more nearly approximate their pre-asymptotic performance in a decision task involving the modality of strength under conditions of no payoff; that is, providing monetary payoff-loss for performance in the weaker modality task will shift performance in that task, in terms of the number of pre-asymptotic anticipatory errors, and therefore number of trials required to reach an asymptote, in the direction of performance in the task involving the modality of strength.

IV. In the repetitive choice situation auditory and visual subjects combined will exhibit stable-state strategies for which the Siegel model will yield quantitatively precise predictions; that is, assuming the auditory and visual tasks

to be alike in all utility-relevant situational features, the model will accurately predict the stable-state strategy behavior of the auditory and visual subjects (treated as a single group) in the visual task from the observed strategy of those same subjects in the auditory task, and vice-versa.

CHAPTER II

DESIGN: SUBJECTS AND PROCEDURE

Subjects

The population sampled was children, age seven years to eight years, three months, attending any of the five summer school centers of District 4J in the Eugene Public School System. It was the opinion of various administrators of the summer school program that the summer school population was not a biased sample of the regular school population and that the summer school group was generally representative of a middleclass socioeconomic level. In the population drawn from the five centers, 26 schools were represented. This representation was preserved in the final sample.

Principals at the five centers were asked to identify all seven-year-olds intending to enroll. The enrollment lists which had been compiled in the spring as a means of anticipating summer school enrollment, were made available to the investigator. Expected enrollees' names were not provided until the week before the session opened by three of the centers and midway into the first week by the two reamining centers. A substantial number of children who had readhed eight years of age had been included in the lists and since there was no way to detect at the outset who these children were (exact ages were obtained from the parents at a later date), the sample age range was expanded to include children up to age eight years, three months. Age was estimated from July first; children whose birthday fell on or before the fifteenth of the month were credited with the next highest month, those falling after the fifteenth were not. Similarly, the original intent of soliciting the help of teachers as well as using school records to eliminate children with sensory handicap (despite corrective aids), known emotional disturbance, deviant school achievement, or sub-normal intelligence had to be abandoned. The administrators of the centers maintained that the records from the schools which the children regularly attended were not available to the summer school staff and most of the teachers were seeing their class members for the first time. For this reason, werwere compelled to rely more heavily on our own judgments plus, statements of parents as the basis on which to exclude a child. After the study was in progress, five children had to be eliminated and replaced, one on the basis of a neurological disorder, one on the basis of extreme emotionality, and the third on the basis of malingering. In such cases the experimental treatment that each of these children would have experienced was administered to his replacement. One mother angrily withdrew her child from the study, on one occasion he had been required to wait one whole hour for the project car to pick him up and on a second occasion, testing at the project center was running lete and he was returned home forty minutes late. A "diplomatic" phone call from the investigator informing the mother of this fact, resulted in the child being withdrawn. The fifth child had to be replaced because she insisted that the decision-machine operators were intentionally making her fail—that each time she made her prediction, they would switch the outcome. It was necessary to spend considerable time with this child showing her the schedules of outcomes and so on in

an effort to convince her that she had not been foiled. She left the testing center unconvinced. Eleven subjects were not included from the outset on the basis that the parents reported a visual, auditory, or emotional problem in their child.

As promptly as the names and addresses were obtained from the summer school center, the parents of each child were sent a letter outlining the investigation, explaining the purposes of the study, and requesting permission for their child to participate. The letter also announced to the parent that a phone call would follow to determine whether or not the family understood the request and to answer any questions they might have to ask the investigator. In every case, an effort was made to have the phone call follow within forty-eight hours of the letter. The letter, the permission slip and the essentials of the phone call are included in Appendix A, page 60, 61, and 62 respectively.

The co-operation of the parents was outstanding; only two mothers refused permission outright. No response was obtained to either the letter or phone call on 23 Ss. Often, near the end of the project, a letter stating that the family had been on vacation would be received along with a request that their child be included in the study if it were not too late. All in all, permission to participate was obtained for 283 children. Each letter had requested parents to include their preferred testing time (day and hour). A second phone call was then made to the parents to confirm the preferred hour or to reschedule the child for another testing time. The research co-ordinator for District 4J Public School System had secured permission for each child to be tested on one occasion (1/2 hour allotted) within school hours in the school setting. The rest of the testing had to be carried out in testing quarters provided by the University, and involved transporting the children to and from their homes in specially insured University vehicles.

All Ss for whom permission was obtained (N = 283) were tested at least once with both the Visual and Auditory Memory Sequencing subtests of the Illinois Test of Psycholinguistic Abilities (ITPA) in its 1968 revised form, (Kirk, McCarthy, Kirk, 1968). The information available on the reliability of these revised tests is presented in Table 15, Appendix A page 63. On the basis of this first testing a tentative separation of "auditory" versus "visual" subjects was made. From the 252 Ss who were successfully administered both sequence tests, Ss who exhibited an 18 month discrepancy between their Auditory and Visual Language Age scores were regarded as having a sensory strength in favour of the modality of the higher score. In all, 120 Ss were identified as either visually or auditorally strong. Nineteen were of the age group 7-0 through 7-3 and of those, eight were judged to be auditorally strong, 11 visually. Forty-two fell into the 7-4 through 7-7 age group, of which 18 were labelled auditorally strong and 25 labelled visually strong. In the 7-8 through 7-11 age group, 37 were identified as having one or the other modality superiority by the 18 month criteria; 19 of these were judged auditorally strong, 18 visually. The oldest group, 8-0 through 8-3, consisted of a total of 21 Ss with 11 auditorally and ten visually superior discrepancies. These data are reported in Table 1, page 15. Any S whose scores showed the 18 month discrepancy was included in a group to be retested with the ITPA Sequencial subtests in order to

TABLE I

SEPARATION OF ORIGINAL SAMPLE INTO "TENTATIVE" MODALITY GROUPS ON THE BASIS OF ITPA SEQUENCING SUB-TESTS LANGUAGE AGE SCORE DISCREPANCIES

	Sample Age Groups				
	7-0:7-3	7-4:7-7	7-8:7-11	8-0:8-3	T
Sample Size					
M	18	47	42	29	136
F.	16	38	42	20	116
T	34	85	84	49	252
Discrepant Scores					
A $\geq$ (V + 18)	8	18	19	11	56
V $\geq$ (A + 18)	11	25	18	10	64
T	19	43	37	21	120

establish the reliability of the separation.

A second, and in some cases third phone call, was made to the parents at this point, to set up and/or confirm an appointment for a second testing. Cooperation from the parents remained at a very high level. All retests were carried out between ten and 14 days of the initial test date. Four graduate students administered the ITPA subtests with the stipulation that all testers administer to approximately the same number of children. Each tester had administered the test at least 15 times before proceeding with the actual data collection. It should be noted here that only the two subtests used in separating the Ss was administered, this fact in itself makes the collection of reliability data rather important.

Pearson Product-Moment Correlations were run on a total of 120 sets of raw scores, 56 sets of which had been identified as reflecting children with superior performance in the auditory modality, and 64 superior in the visual. The test-retest data yielded a coefficient of .55 for the Visual-Memeory Sequencing Test and one of .91 for the Auditory-Memory Sequencing Test. These test-retestsdata are included in Appendix A, Table 16, pages 64-70. It was decided at the outset that unless the test-retest correlation coeffieients reached at least .85 the intended comparison of auditory vs. visual performers could not be carried out. It was concluded that the coefficient of .55 does not allow for reliable separation of auditory or visual Ss on the basis of comparatively superior functioning. The original focus of the study, a comparison of superior auditory vs. superior visual performers' (as identified on the ITPA Sequencing Tests) strategy behavior in a specific decision task had to be abandoned. The investigation from this point forward essentially became a within-auditory-modality comparison. High and low auditory performers identified by their performance on the ITPA Sequencing subtests were compared in an auditory decision task. The hypotheses were revised to accommodate the change and are stated below in their revised form.

In the repetitive choice situation:

I. subjects, for whom an auditory decision task represents processing information via a weak modality, will more nearly approximate a pure stable-state strategy than will subjects for whom the task represents information processing via a strong (auditory) modality,

II. subjects, for whom the auditory decision task requires processing information via a weak (auditory) modality, experience greater series unexpectedness in the pre-asymptotic aspect of a decision task than do Ss for whom the task requries information processing via a strong (auditory) modality; that is, prior to reaching an asymptote, the subjects for whom the task involves stimulus input to a strong modality, will accurately anticipate a greater proportion of the events and will therefore arrive at their asymptotic level earlier in the series;

III. subjects, for whom the auditory decision task represents processing information via a weak modality and, who are required to perform under conditions of risk (payoff-loss), will, in their pre-asymptotic performance, perform in such a way as to more nearly approximate the pre-asymptotic performance of Ss for whom the task represents processing via a strong modality and who are performing under no-payoff conditions; that is, providing monetary payoff-loss to Ss for whom information has been presented to a weak auditory modality, will shift performance in terms of pre-asymptotic errors, in the direction of the performance exhibited by Ss for whom the task represents processing information in a strong modality under no-payoff;

IV. high and low auditory subjects will exhibit stable-state strategies for which the Siegel Model will yield quantitatively precise predictions; that is, assuming the auditory and visual tasks to be alike in all utility-relevant situational features, the model will accurately predict the stable-state strategy behavior of the high and low auditory Ss (treated as a single group) in the auditory task from the observed strategy of those same subjects in the visual task.

The sample was "re-opened" to include all of the original Ss for whom we had received participation permission and for whom we had ITPA Auditory Sequencing scores. High vs. low auditory sequencers were identified in terms of Language Age scores obtained on the <u>first</u> testing with the ITPA Auditory-Memory Sequencing subtest. It is recommended by the authors of the ITPA 1968 revision that investigators not use Language Age scores when comparing across modality performance, but Language Age Scores are regarded as appropriate for making <u>within</u>-modality comparisons.

The original pool of Ss tested were separated into sub-groups according to ITPA norm groups established by 4 month age periods. In the age group 7-0 through 7-3, 34 Ss were tested; in the group 7-4 through 7-7, 85 Ss were tested; in the group 7-8 through 7-11, 84 Ss were tested; and in the group 8-0 through 8-3, 49 Ss were tested. In all, a total of 136 males and 116 females were tested. Mean Auditory Language Age and standard deviation by age group from youngest to oldest, for the overall, for males, and for females respectively were: for 7-0 through 7-3, $\bar{X}$s were 87.618, M 83.167, F 92.625; SDs were 20.15, M 22.13, F 16.26; for 7-4 through 7-7, $\bar{X}$s were 84.338, M 85.787, F 82.657; SDs were 19.31, M 18.51, F 20.12; for 7-8 through 7-11, $\bar{X}$s were 87.893, M 88.143, F 87.643; SDs were 19.02, M 19.14, F 18.90; finally for the 8-0 through 8-3 age group the $\bar{X}$s were 86.816, M 83.379 and F 91.800; the SDs were 20.47, M 20.78, and F 18.94. These data are displayed in Table 2, page 18.

To determine whether or not any of the groups were different, t-tests and F ratios were run on the extreme groups. The youngest and oldest female subjects did not differ from each other nor from their male agemates in neither central tendency nor variability. However, they were found to differ in central tendency from a composite of all other groups ($\bar{X}$ = 85.513 and s = 19.50) from whose variance their variance did not differ significantly. The critical $t_{.025}$ value was 1.96; the obtained t

TABLE 2

MEAN AND STANDARD DEVIATION FOR THE ORIGINAL POOL OF Ss BASED ON THE AUDITORY SEQUENCING TEST SCORES EXPRESSED IN LANGUAGE AGE FOR SEPARATE AGE GROUPS

Age Group		N	X	X^2	$\bar{X}$	SD
7-0	M	18	1497	133317	83.167	22.13
through	F	16	1482	141498	92.625	16.26
7-3	T	34	2979	274815	87.618	20.15
7-4	M	47	4032	361998	85.787	18.51
through	F	38	3141	275013	82.657	20.12
7-7	T	85	7173	637011	84.388	19.31
7-8	M	42	3702	341694	88.143	19.14
through	F	42	3681	337617	87.643	18.19
7-11	T	84	7383	679311	87.893	19.02
8-0	M	29	2418	214128	83.379	20.78
through	F	20	1836	175716	91.800	18.94
8-3	T	49	4254	389844	86.816	20.47
	GT	252	21,789	1,980,981	86.464	19.25

between the means was 2.022. Because this female subgroup difference existed, it was necessary to select high and low performers from this group separated from those of all other subgroups combined. Separate confidence intervals were established for the mean of each of the two groups; one, for children aged 7-0 through 8-3 combined, excluding the females from the 7-0 through 7-3 and 8-0 through 8-3 age groups, and one for the mean of these two female age groups combined. The confidence interval for the larger group with $a = .05$ was $C(82.083 < M < 88.943) = .90$. The confidence interval for the deviant female age groups at .05 was $C(84.40 < M < 99.94) = .90$ (Walker and Lev, page 149). An attempt was made to draw the sample of Ss so that low auditory Ss would be those whose scores fell one standard deviation or more below the lower limit of the relevant confidence interval, and so that high auditory Ss would be those whose scores fell one standard deviation above the upper limit of that interval. Recall that $S = 19.50$ for the larger group and 17.81 for the deviant females. Rounded, the upper limit for low performers was set at 63 for the larger group and the lower limit for the high performers was set at 108; while the upper limit for the deviant females for low performers was set at 67 and the lower limit for high performers set at 117. These limits could not be held to, however, since they yielded only 53 low performers (32 males, 21 females) and 43 high performers (22 males, 21 females). The test of the hypotheses required 50 low performers and 30 high performers, consequently the upper limit of low performers had to be extended upward to 78 in order to get the required number of four additional females. As it happens the four females were pulled (via a random number table) from the deviant female group. Their scores were 72, 78, 78, and 78. The three Ss that had to be added for high performers were females and were drawn from the deviant female group also. Their scores were 111, 111, and 114. At the time the original Ss were drawn, six replacements were drawn for each sex group within the high and low performers. The sample ($N = 80$) was then randomly assigned to the four hypotheses with the one stipulation that an equal number of boys and girls within high and low ITPA performance groups be assigned to the hypotheses as required. The data for hypotheses I and II were collected on the same 40 Ss. The mean Auditory-Memory Sequencing scores and the standard deviation for each sex-group within the high and low performers was calculated: the high female group, sho had a mean CA of 91.3 months had a mean LA score of 116.70, ($s = 9.90$); the high male group, with a mean CA of 92.6 months, had a mean LA score of 116.10, ($s = 7.11$); the overall La mean for high performers with mean CA of 91.90 is 116.40, ($s = 8.62$ months). In contrast the low performers group assigned to the test of hypotheses I and II is composed of a female group with mean CA of 93.0 and mean LA of 61.80, ($s = 6.74$); a mean of 62.4, ($s = 3.23$) was found for low male performers (CA $= 93.0$); and an overall mean CA of 93.0 with overall mean auditory Language Age of 62.1, ($s = 5.29$).

By design the 20 Ss assigned to hypothesis III were all from the low Language Age pool. The ten low males had a mean chronological age of 91.9 months, and a mean auditory Language Age of 61.8 months, ($s = 6.74$). The ten low females had a mean CA of 91.5 months, and a mean LA of 63.9 months. The overall mean CA was 91.70 and the mean LA was 62.85 months, ($s = 5.55$). Finally, of the 20 Ss assigned to the test of hypothesis IV, the high females had a mean CA of 92.2 and their mean

Language Age was 117.60, (s = 9.37). The high males had a mean CA of 92.5 with a mean LA of 121.20. The low Ss had a mean CA of 90.15, a LA of 61.50, (s = 4.36) with mean low male CA of 89.5, mean LA of 60.0 (s = 5.92) and low female mean CA of 90.8, with mean LA of 63.0, these data are summarized in Table 3, page 21.

The individual Auditory-Memory Sequencing scores are displayed by hypothesis along with other identifying information (summer school and regular school, time tested, tester and child's code in Table 17, Appendix A, pages 71 through 74.

Procedure

The experimental situation designed to test the hypotheses was a variant of that developed by Humphreys (1939) which has been typically used to study human learning in the repetitive choice situation. In all tests, save the quantitative test of Siegel's decision model, the type of stimulus event upon which the subject was required to base his choices was auditory; in the quantitative test an additional condition involving a visual stimulus was included. In the auditory decision task the child was required to predict (choose) which of two tones would occur, a steady tone or a pulsing tone. In the visual decision situation the child was required to choose between two visual stimuli, a steady or flashing red light. In either task, the set up was such that one of the two events occurred more frequently than the other. The auditory task in all tests involved a 75:25 event split. The visual task involved a 65:35 split. Except where required as part of the experimental tests (test of Hypothesis III) all Ss were run under a no-payoff condition in both tasks. That is, the experimenter did not offer any specific reward for a correct response, since it was expected that reward in such a simple task may mask differences between the usual tendencies of high and low performers. It was further assumed that, on the average, children in our culture are adequately motivated toward "being right" or "correct" to try to do well in this situation. Individual differences in motivation were assumed to be controlled through random assignment of the Ss to the various experimental conditions. In this experimental situation, a correct response is defined as one wherein the S predicts (chooses) the event which actually occurs on a given trial. The situation can be depicted as follows:

(1) Trial Onset	(2) Subject Predicts	(3) Event Occurs	(4) Consequences
Signal light comes on	Event #1 or Event #2	Event #1 or Event #2	(feedback) right or wrong

The experimental apparatus used for all tests was the same; namely, a black galvanized-tin box, thirty inches high and eighteen inches wide which has two lights, attached in a shield at the top, designed to flood the entire front panel of the box to signal the onset of a trial. An opaque glass window, two and a half inches in diameter, is centered four inches from the top of the box. A red plastic shield is attached to the window on the inside, behind which a five watt light bulb is mounted.

TABLE 3

AUDITORY SEQUENTIAL LANGUAGE AGE AND CA STATUS OF SUBJECTS ASSIGNED TO THE FOUR HYPOTHESES

	Group	N	CA* Mean	Language Age* Mean	s
Hy. 1 & 2					
	High Auditory Females	10	91.30	116.70	9.90
	High Auditory Males	10	92.60	116.10	7.11
	Total High Auditory Ss	20	91.90	116.40	8.62
	Low Auditory Females	9	93.00	61.80	6.74
	Low Auditory Males	10	93.00	62.40	3.23
	Total Low Auditory Ss	19	93.00	62.10	5.29
Hy. 3					
	Low Auditory Females	10	91.50	63.90	4.36
	Low Auditory Males	10	91.90	61.80	6.74
	Total Low Auditory Ss	20	91.70	62.85	5.55
Hy. 4					
	High Auditory Females	5	92.20	117.60	9.37
	High Auditory Males	5	92.50	121.20	10.75
	Total High Auditory Ss	10	92.35	119.40	10.06
	Low Auditory Females	5	90.80	63.00	8.75
	Low Auditory Males	5	89.50	60.00	5.92
	Total Low Auditory Ss	10	90.15	61.50	7.34

* Age Scores in Months

Slightly below, a three inch speaker is mounted through which the auditory signals are automatically emitted. The heart of the electric system consists of a single cycle industrial timer that activates a series of five (5) cam operated switches. The timer completes one revolution each time the "cycle-start" switch is depressed. During each revolution the five cam operated switches activate the various functions in sequence. The functions (visual-audio, pulse-continuous) are selecteded in advance by manually presetting two toggle-switches. All controls to operate the system are located on the rear panel and include indicator lights to alert the operator to pre-set the functions for the next cycle and to start the cycle. It was necessary to build (and use) two event machines in order to test the Ss in the allotted time.

In both the auditory and visual task the steady signal duration is constant at two and one-quarter seconds. The automatic timer also insures consistency in both the steady and pulsing signals from trial to trial and subject to subject. The pulsing signal consists of three distinctly separate pulses of sound or light depending upon whether the task is auditory or visual. The duration of the pulses is three-fourths seconds each separated by a one-fourth second interval. Efforts were made to keep extraneous stimulation to a minimum during the tests. At the outset each S was tested on the apparatus in order to determine whether or not he could make the necessary sensory discriminations. Subjects were admitted to the experiment on that basis and no distinction was made for the S between these "practice" trials and the real task.

The formal characteristics of this study can be described as follows: In a simple prediction task, marginal utility of a correct response is assumed to be constant over the two conditions of stimuli being presented visually or auditorally; whereas, marginal utility of choice variability is assumed to vary <u>within</u> the situations for the auditorally strong and auditorally weak performers. The other independent variables which are identified in the model and which were held constant within all experiments are: the number of alternatives (K = 2), and the event probabilities (π_1 = .75, π_2 = .25 in the auditory situation and π_1 = .65, π_2 = .35 in the visual situation). Random selection and assignment of the Ss was employed to control for individual differences in relevant variables such as motivation, intelligence, sensory acuity and the like, as well as for order and practice effects.

The decision-making situation, the S seated in front of the decision box is instructed by E, as follows "(child's name), today I want you to play a game with me. This is (E_2's name). She is going to operate the game machine. See this little |speaker / window| (E_1 points to the |speaker / window|)? After this signal light comes on, (E_2 turns on flood light with other switches in neutral position) like this, (pause) |a tone will come through the speaker / a red light will glash in the window.| Sometimes it will |sound / flash| three times, sometimes it will |sound / flash| once. (E_2 starts cycle with switch on 'Pulse'). This is what it is like when it |sounds / flashes| three times.

(Pause) (E_2 waits for cycle to finish and starts new cycle on 'change' signal. This is what it is like when it sound once. (Pause) (E_2
flashes
at finish of cycle, switches on flood light with other switches in neutral position to signal the onset of a new trial). Each time this light comes on, I want you to tell me as quickly as you can, what you think will happen and I'll write it down here. If you think it will sound three times, say 'three'. If you think it will sound once,
flash flash
say 'one'. Do you understand? (If S says no, repeat directions from 'Each time....etc.) "Now remember, when you see this light (E_2 turns on Signal Light) you have to tell me whether you think it will be <u>one</u> or whether you think it will be <u>three</u>. Try to be right as often as you can. All right, let's begin."

Each S had three randomly generated test trials before the series proper began, but there was no distinction made for the S between the test trials and the actual sequence. Only one S had difficulty with the directions; this S had epilepsy and had to be replaced.

The order in which the two events occurred from trial to trial was random with two restrictions: (1) in no instance was the more frequent event allowed to occur more than six times in succession, and (2) the event probability distribution (usually 75:25) was maintained within each 20 trial block. In all hypotheses, except hypothesis IV, each S underwent 200 trials in the auditory decision situation and the stable-state was designated as the last block of 20 trials (trials 181-200). In the fourth hypothesis the Ss were exposed to 160 trials only and the stable-state was designated as trials 141-160 inclusive. The reasoning behind shortening the test rests in the possibility that 400 trials under a no-payoff regine may have pushed the concept of a monotonous task to the point where subject loss would have been overwhelming.

The Ss, who were randomly drawn and assigned to each treatment to counter-balance any within-task stimulus preferences, were required to perform individually, whether in the auditory or visual task. Which event became the more frequent event (i.e., pulsing or steady signal) was randomly determined through a coin toss procedure. The stipulation was imposed that equal numbers of high and low auditory Ss experience each.

In an attempt to minimize unnecessary problems of scheduling, a set of orders was established before hand for each of the Ss (i.e., for numbers 1 to 80), so that availability of an S for testing determined which number with its predetermined order set he received. To control for possible systematic effects arising out of accidental features of any particular random series, six different random series, four in which $\pi_1 = .75$, two in which $\pi_1 = .65$ were generated and equal numbers of Ss from the high and low groups were assigned each series. The Ss' choice or prediction was recorded for each trial, in all cases, on a record sheet beneath the record of the actual event. The actual event record allowed for ease of scoring as well as a helpful check against errors in case the machine operator presented the series inaccurately.

In order to obtain data for the test of hypothesis I and II, the frequency with which 40 randomly assigned Ss, twenty High Auditory-Memory Sequencers (HAMS) and twenty Low Auditory-Memory Sequencers (LAMS), selected the more frequently occurring event in a random series of pulsing and steady tones was tabulated for the final twenty trials (stable-state)*. Also the cumulative error score to stable-state, that is, across the first 180 trials, was calculated. An error is here defined as the child predicting, on any given trial, the event alternative to the one which actually occurred. Similarly, data for the hypothesis III test consisted of the stable-state strategies adopted by twenty Low Auditory Memory Sequencers under conditions of risk and the stable-state strategies adopted by twenty LAMS under "non-risky" conditions. The data for the low or no risk conditions was the same referred to and used in the test of hypothesis I and II above. Conditions of risk refer to a payoff-loss condition under which the Ss were run. Specifically, Ss received one cent for each correct prediction and lost one cent for each incorrect prediction. Each S under payoff-loss was given a 25¢ pot with which to play the game, was allowed to keep his earnings, and so informed at the outset. The change in the instructions for children playing the game under payoff-loss was as follows: Following the question "Do you understand?", see page 23 of this text, E, says: "We're going to play the game with money. This is your money (E points to pile of coins farthest from S). Each time you are right, I'll give you a penny; each time you are wrong I'll take one of <u>your</u> pennies. We have to play as fast as we can so I'll handle the money. Now remember, when you see this light you have to tell me whether you think it will be <u>one</u> or whether you think it will be <u>three</u>. Try to be right as often as you can. ---You can keep all the money you have in your pile when we're through. All right, let's begin." (It was in the running of this test that one little girl believed, and persisted in believing, that the machine operator was "rigging" the outcomes against her. The S was replaced, but as it turned out E_2, it seems, had induced the suspicion in the child by busily erasing some check marks on her event series sheet while the test was in progress.) Cumulative error scores to stable-state were tabulated for this test also, using the data from the payoff-loss and no-payoff groups discussed above.

In order to obtain data for the test of hypothesis IV, twenty additional Ss who were randomly assigned from the High and Low Auditory S pools were required to make choices in 160 trials. Each S performed individually in both an auditory and visual probabilistic decision task. In an effort to control order and practice effects, the order in which the Ss were administered the two tasks was randomly determined. Subjects required to perform in the auditory task first, were presented with the visual task on the second occasion, and vice-versa. On the average, Ss were tested two days apart in the two decision tasks. In this test, Ss experienced the auditory task with the more frequent

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* The terms "HAMS" and "LAMS" as used from this point forward, refer to Ss selected to represent High and Low performers on the ITPA Auditory Sequential Test of immediate memory.

event occurring randomly on 75% of the trials within each trial block. They experienced the visual task with π_1 set at .65.

CHAPTER III

THE DATA AND THEIR TREATMENT

In order to test hypothesis I, which states that stable state strategies (SSS) in the auditory decision task do not differ for high auditory memory sequencers (HAMS) vs. low auditory memory sequencers (LAMS), p_1, the proportion of trials within the final trial block on which the child predicted the most frequently occurring event, was computed for each S. In general, it was found that the scores ranged from .20 to 1.00 with an overall median stable state score of .60. Males obtained scores ranging from .45 to 1.00 with a median of .675. Male HAMS' scores ranged from .45 to .90 with their median score falling at .675; male LAMS' scores ranged from .45 to 1.00 with a median score of .625. Females, on the other hand obtained scores ranging from .20 to .85 with a median of .600. Female HAMS had a range of scores from .40 to .85 with a median of .750; female LAMS obtained a performance range from .45 to .80 with a median of .550*. These data are reported in Table 4 page 27. All test results for hypothesis I are summarized in Table 5, page 28.

Prior to comparing high and low auditory Ss the SSS data were checked for sex differences within high and within low performance groups by use of a Mann-Whitney U two-tailed test at the 5% level of confidence, (Siegel, page 116). The obtained U for high performera (HAMS) was 47.5 which exceeded the critical table value of $U \leq 23$ (Siegel, page 276).and which, therefore, could not be regarded as reflecting a significant sex difference. The obtained U of 38.5 for the sex comparison within low auditory memory sequencers also exceeded the critical value of $U \leq 20$ and offered no support for the existence of a sex difference within LAMS. These results are reported in Table 18, Appendix B, page 76. The negative results obtained in the sex difference comparisons made it possible to combine the data across sex to provide a stronger test for a possible high A-MS vs. low A-MS group difference in stable-state decision strategies. Again the Mann-Whitney U test was applied to the data. This time a one-tail test was appropriate since a difference in favour of low performers was predicted. HAMS' strategies ranged from .40 to .90 (N=20) with a median of .675 ($\bar{p}$ = .675); LAMS' scores ranged from .45 to 1.00 (N=19) with a median of .550 (mean $\bar{p}$ = .637). The obtained U of 156 exceeds the critical table value of $U \leq 130$ (Siegel, page 277) and provides no support for the notion that low auditory memory sequencers select higher stable state decision strategies than do high sequencers when required to perform in an auditory decision task. In fact, the data run counter to the hypothesis. These results are reported in Table 19,

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* Any calculations or tests in H_1 involving females excludes the female subject whose SSS was .20 since, on the basis of individual performance, it was obvious that she was not "playing the game". The median for LAMS excluding the S whose score was .20 remains unchanged at .550.

TABLE 4

DISTRIBUTION OF STABLE-STATE STRATEGIES BY SUB-GROUPS FOR H_1

					HAMS		LAMS	
SSS	Boys N=20	Girls* N=20	HAMS N=20	LAMS N=19	Male N=10	Female N=10	Male N=10	Female N=9
.10								
.20		X						
.30								
.40		X	X			X		
	XXX	X	X	XXX	X		XX	X
.50	X	XX	X	XX		X	X	X
	XXXX	XXXX	XXX	XXXXX	XX	X	XX	XXX
.60		XXX	XX	X		XX		X
	XX	X	XX	X	XX			X
.70	XXX	X	XX	XX	XX		X	X
	XX	XXX	XXXX	X	X	XXX	X	
.80	X	X		XX			X	X
		XX	XX			XX		
.90	XX		XX		XX			
1.00	XX			XX			XX	
Total	13.55	12.15	13.40	12.10	6.80	6.60	6.75	5.35
$\bar{p}$	.678	.608	.670	.637	.680	.660	.675	.594
Median	.675	.600	.675	.550	.675	.675	.625	.550

* The S whose SSS was .20 is eliminated from all other sub-groups since she did not "play the game".

TABLE 5

MANN-WHITNEY U TESTS FOR SIGNIFICANCE OF DIFFERENCES
IN SSS FOR WITHIN AND BETWEEN AUDITORY STRENGTH GROUPS

Group	U	a	Critical Value	Significance
HAMS (N=20)				
Females vs. Males (N=10) (N=10)	47.5	.05	U _ 23**	No
LAMS (N=19)				
Females vs. Males (N=9) (N=10)	28.5	.05	U _ 20**	No
HAMS vs. LAMS (N=20) (N=19)	156.0	.05	U _ 130*	No

* one-tailed test
** two-tailed test

higher stable state decision strategies than do high sequencers when required to perform in an auditory decision task. In fact, the data run counter to the hypothesis. These results are reported in Table 19, Appendix B, page 77.

Hypothesis II predicts a difference in pre-stable state performance between HAMS and LAMS in terms of total number of errors each S made in his predictions of the events on trials one through 180. Recall that an error is defined as S predicting the event which in fact does not occur on a given trial and/or, failure to predict the event before it occurs. The data show an overall range of 42 errors extending from 59-100 out of a possible 180. The boys' error scores ranged from 62 (34.4%) to 100 (55.6%) while girls scores ranged from 59 (32.7%) to 98 (54.4%). The median error score for the two groups is 76 (mean, 79.80) for boys, 81 (mean, 79.21) for girls. Within the male group male HAMS obtained a median error score of 76 (mean, 79.50) while male LAMS obtained 77 as their median (mean, 80.10). Within the female group, female HAMS have a median of 71 (mean, 73.90) while LAMS obtained a median of 84.00 (mean, 86.11). HAMS as a group show a median of 75.50 (mean, 76.00) in contrast to LAMS whose median error score is 82 (mean, 82.47). These data, in conjunction with individual error scores and their equilalent proportions, are reported in Table 6, page 30.

In order to test for differences in pre-stable-state performance, each error score was converted to its proportion equivalent, the frequency of various error proportions obtained within each sub-group was tabulated and frequency distributions were then set up. These results are reported in Table 7, page 31. It should be noted that the female's score, eliminated from the LAMS group in the previous tests, was replaced by the LAMS mean error score for all tests of hypothesis II. In addition, note that all tests of hypothesis II were made using the Kolmogorov-Smirnov two sample test for independent samples, (Siegel, page 127). The test is a non-parametric which is sensitive to any kind of difference (central tendency, dispersion, skewness) between the cumulative distributions from which the two samples were drawn. All tests were run at the .05 level of confidence. These results are summarized in Table 8, page 32. Before the main comparison of HAMS vs. LAMS could be made, a within auditory group test was made on both groups to check for sex differences.

Error scores by sex within auditory group along with the test on their cumulative frquency distributions are shown in Table 20, Appendix B, page 78. The maximum discrepancy (K_D max.) found between male and female LAMS was five and that found between male and female HAMS was three. Neither of these discrepancy values reach the critical value $K_D \geq 7$ required for a two-tailed test at the 5% level where $n_1 = n_2 = 10$ (Siegel, page 278). Since the obtained differences between males and females were not significant, the sex groups were combined within auditory groups in order to allow for a stronger test (N = 20) for a difference between the two auditory groups. The comparison yielded a maximum discrepancy of 8 between the HAMS and LAMS in favour of the former. A one-tailed test at the 5% level with N = 20 requires a discrepancy equal to, ot greater than, 8 in order to be significant. The results are to be found in Table 21, Appendix B, page 79. Obviously,

TABLE 6

DISTRIBUTION OF PRE-STABLE-STATE (trials 1-180) ERROR SCORES FOR SUB-GROUPS OF HYPOTHESIS II

Errors to Stable State	Boys (N=20)	Girls (N=19)	HAMS (N=20)	LAMS (N=19)	Male (N=10)	Female (N=10)	Male (N=10)	Female (N=9)
58-62	X	X	X	X		X	X	
63-67	X	XXXX	XXXXX		X	XXXX		
68-72	XXXX		X	XXX	X		XXX	
73-77	XXXX	XXX	XXXXXX	XX	XXXX	XX	X	X
78-82	XX	XXXX	XX	XXXX	X	X	X	XXX
83-87	X	XX		XXX			X	XX
88-92	XX	XXX	XXX	XX	XX	X		XX
93-97	XX	X	X	XX		X	XX	
98-102	XX	X	X	XX	X		X	X
Total Errors	1596	1505	1534	1567	795	739	801	766
Mean	79.80	79.21	76.00	82.47	79.50	73.90	80.10	86.11
Median	76.00	81.00	75.50	82.00	76.00	71.00	77.00	84.00
Mean p	0.885	0.458	0.431	0.493	0.442	0.421	0.443	0.478
Median p	0.422	0.451	0.419	0.456	0.422	0.395	0.427	0.467

TABLE 7

CUMULATIVE FREQUENCY DISTRIBUTIONS OF PROPORTION OF ERRORS IN PRE-STABLE-STATE TRIALS FOR SUB-GROUPS OF HYPOTHESIS II

	Error Proportion Frequencies Cumulated							
					HAMS		LAMS	
Cumulative Error Proportion Interval	Boys (N=20)	Girls (N=20)	HAMS (N=20)	LAMS (N=19)	Male (N=10)	Female (N=10)	Male (N=10)	Female (N=9)
.321 - .330	0	X 1	X 1	0	0	X 1	0	0
	0	1	1	0	0	1	0	0
.341 - .350	X 1	1	1	X 1	0	1	X 1	0
	X 2	1	X 2	1	X 1	1	1	0
.361 - .370	2	XXXX 5	XXXX 6	1	1	XXXX 5	1	0
	2	5	6	1	1	5	1	0
.381 - .390	XX 4	5	6	XX 3	1	5	XX 3	0
	XX 6	5	X 7	X 4	X 2	5	X 4	0
.401 - .410	X 7	5	X 8	4	X 3	5	4	0
	XXX 10	5	XX 10	4	XX 5	5	X 5	0
.421 - .430	X 11	XXX 8	XXX 13	X 5	X 6	XX 7		X 1
	X 12	X 9	X 14	XX 7	6	X 8	X 6	1
.441 - .450	X 13	XX 11	X 15	XX 9	X 7	8	6	XX 3
	13	X 12	15	X 10	7	8	6	X 4
.461 - .470	13	X 13	15	X 11	7	8	6	X 5
	13	X 14	15	X 12	7	8	6	X 6
.481 - .490	X 14	X 15	15	XX 14	7	8	X 7	X 7
	X 15	XX 17	XX 17	X 15	X 8	X 9	7	X 8
.501 - .510	X 16	17	X 18	15	X 9	9	7	8
	16	17	18	15	9	9	7	8
.521 - .530	XX 18	X 18	X 19	XX 17	9	X 10	XX 9	8
	18	18	19	17	9	10	9	8
.541 - .550	X 19	X 19	19	XX 19	9	10	X 10	X 9
	X 20	19	X 20	19	X 10	10	10	9

TABLE 8

KOLMOGOROV-SMIRNOV TESTS FOR SIGNIFICANCE OF DIFFERENCES IN CUMULATIVE ERROR FREQUENCIES TO STABLE-STATE FOR WITHIN AND BETWEEN AUDITORY STRENGTH GROUPS

Group	K_D Max	a	Critical Value	Significance
HAMS (N=20) Females vs. Males (N=10) (N=10)	4	.05	K_D _ 7**	No
LAMS (N=20) Females vs. Males (N=10) (N=10)	5	.05	K_D _ 7**	No
HAMS vs. LAMS (N=20) (N=20)	8	.05	K_D _ 8*	.05
Males (N=20) HAMS vs. LAMS (N=10) (N=10)	2	.05	K_D _ 6*	No
Females (N=20) HAMS vs. LAMS (N=10) (N=10)	7	.05	K_D _ 6*	.05

* one-tailed
** two-tailed
the mean frmale LAMS' score was substituted in for the score of the female eliminated from this group

the difference in the distributions is significant in the predicted direction and it can be concluded that the values of the population from which the HAMS sample was drawn are statistically larger than those of the one from which the LAMS was drawn, and the difference cannot be accounted for by random deviations.

Considering the statistical fact that high auditory memory sequencers exhibit a lower error performance than those regarded as low auditory performers, it was essential to check for a within sex difference. That is, to determine whether HAMS of either or both sexes were superior to LAMS of either or both sexes. Under a one-tailed test at the 5% level (N=20), the obtained discrepancies showed the superiority of HAMS over LAMS to hold for females only. Male HAMS vs. LAMS showed an insignificant discrepancy (K_D max. = 2) and the female HAMS vs. LAMS discrepancy (K_D max. = 8) is significant at the 1% level of confidence. These data are reported in Table 22, Appendix B, page 80.

Hypothesis III states, in effect, that the performance of Low Auditory Memory Sequencers, under conditions of meaningful reinforcement (payoff-loss) will more nearly approximate that of a High Auditory Memory Sequencing group than they will that of their low auditory but "unrewarded" (no-payoff) counterpart. The test involved a comparison of LAMS both on the stable-state strategy adopted and on the proportion of errors cumulated to the stable-state, that is, across the first 180 trials. The stable-state strategies were compared using a Mann-Whitney U test for independent samples and the distributions of cumulated error proportions were compared via the application of the Kolmogorov-Smirnov two sample test. It should be noted that the "no-payoff" LAMS are the identical 19 Ss used in the test of hypothesis I. Once again the mean score of the female LAMS (no-payoff) group was substituted for the score of the female LAMS subject who had to be eliminated from the analysis. The results of all tests for hypothesis III are summarized in Table 9 and 10, page 34 and 35, and the performance curves relevant to all three hypotheses are depicted in Figure 1, page 36.

The distribution of stable-state strategies for the Low Auditory Memory Sequencing sub-groups are reported, along with their mean and median strategies, in Table 11, page 37.

The range of strategies adopted across Pay-off conditions was identical for boys and girls and extended from .45 to 1.00. The median strategy adopted by boys (N=20) was .800, the mean was .740. The median strategy for girls (N=19) was .750, and the mean was .716. Payoff-loss males (N=10) exhibited a range of strategies from .55 to 1.00 with a median of .850 and a mean of .805 as opposed to their No-payoff counterparts for which the range was .45 to .80 with a median of .625, and a mean of .675. Females under the Payoff-loss condition (N=10), on the other hand, exhibited strategies ranging from .45 to 1.00 with a median identical to that of Payoff-loss boys (.850) and a mean of .825. Their No-payoff female counterparts scores (N=9) showed a range identical to that of Payoff-loss boys (.45 to .80), a median of .550 and a mean of .594. The overall Payoff-loss range of scores was from .45 to 1.00

TABLE 9

MANN-WHITNEY U TEST FOR SIGNIFICANCE OF DIFFERENCES IN SSS FOR WITHIN AND BETWEEN PAYOFF CONDITIONS

Group	U	a	Critical Value	Significance
LAMS Payoff-Loss (N=20)				
Female vs. Males (N=10) (N=10)	43.5	.05	U _ 23**	No
LAMS No-Payoff (N=19)	28.5		U _ 20**	No
Females vs. Males (N=9) (N=10)				
LAMS Payoff-Loss vs. No-Payoff (N=20) (N=19)	76.5	.05	U _ 130*	.001
Male LAMS				
Payoff-Loss vs. No-Payoff (N=10) (N=10)	28.0	.05	U _ 27*	No
Female LAMS				
Payoff-Loss vs. No-Payoff (N=10) (N=9)	11.0	.05	U _ 24*	.001
HAMS No-Payoff (N=20) vs. LAMS Payoff-Loss (N=20)	84.5	.05	U _ 138*	.001

* one-tailed
** two-tailed

TABLE 10

KOLMOGOROV-SMIRNOV TEST FOR SIGNIFICANCE OF DIFFERENCES
IN PRE-STABLE-STATE ERROR FREQUENCIES FOR WITHIN
AND BETWEEN PAYOFF CONDITIONS

Group	K_D Max	a	Critical Value	Significance
LAMS Payoff-Loss (N=20)				
Females vs. Males (N=10) (N=10)	3	.05	K_D _ 6**	No
LAMS No-Payoff (N=20)				
Females vs. Males (N=10) (N=10)	5	.05	K_D _ 6**	No
LAMS Payoff-Loss vs. No-Payoff (N=20) (N=20)	8	.05	K_D _ 8*	.05
Male LAMS				
Payoff-Loss vs. No-Payoff (N=10) (N=10)	3	.05	K_D _ 6*	No
Female LAMS				
Payoff-Loss vs. No-Payoff (N=10) (N=10)	8	.05	K_D _ 6*	.01

* one-tailed
** two-tailed
the mean female LAMS' score was substituted in for the score of the female eliminated from this group

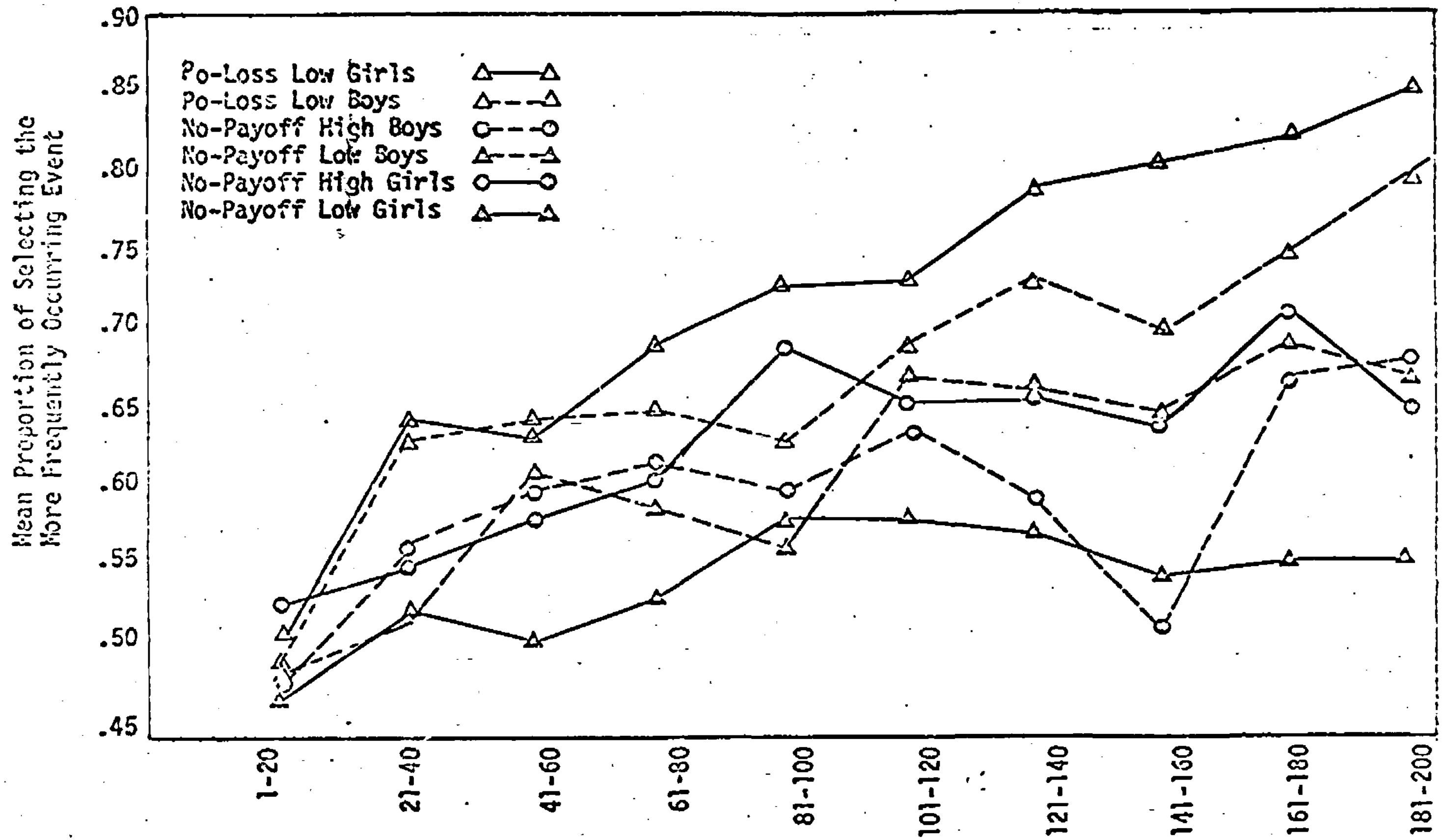

Figure 1.0 Mean Performance for High and Low Ss, by sex, under different payoff conditions.

TABLE 11

DISTRIBUTION OF STABLE-STATE STRATEGIES BY SUB-GROUPS OF LAMS OF HYPOTHESIS III

			Po Condition		Po-Loss		No-Po	
SSS	Boys (N=20)	Girls (N=19)	Po-Loss (N=20	No-Po (N=19)	Male (N=10)	Female (N=10)	Male (N=10)	Female (N=9)
.40								
.45	XX	XX	X	XXX		X	XX	X
.50	X	X		XX			X	X
.55	XXX	XXX	X	XXXXX	X		XX	XXX
.60		X		X				X
.65	X	X	X	X				X
.70	X	X		XX			X	X
.75	X	XX	XX	X		XX	X	
.80	YXX	XX	XXX	XX	XX	X	X	X
.85	XXXX	XX	XXXXXX		XXXX	XX		
.90	X	X	XX		X	X		
.95	X	XX	XXX		X	XX		
1.00	XX	X	X	XX	X	XX		
Total	14.800	13.600	16.300	12.100	8.050	8.250	6.750	5.350
Mean	0.740	0.716	0.815	0.637	8.805	0.825	0.675	0.594
Median	0.800	0.750	0.850	0.550	0.850	0.850	0.625	0.550

with a median of .850 and a mean of .815. Whereas, the overall No-payoff range of scores was the same as that for the Payoff-loss group, their median strategy turned out to be .550 and their mean to be .637.

Prior to testing for differences in LAMS scores under the separate Pay-off conditions it was essential to determine whether the males' and females' scores could be combined within the Pay-off loss group, thereby, providing a stronger test. Recall that no sex differences were found within the No-payoff group. (Refer to Table 18, Appendix B, page 76.) A Mann-Whitney U two-tailed test for sex difference within the Payoff-loss LAMS yielded a U of 43.5 and for which the critical value is $U \leq 23$. These findings are reported in Table 23, Appendix B, page 81. It was concluded that no significant sex difference existed in the level of SSS adopted in the sample of Payoff-loss LAMS and that the sex groups might, therefore, be combined for a test of between payoff conditions differences.

The U obtained in the one-tailed test comparison of Payoff-loss LAMS with No-payoff LAMS was 76.5 and is significant beyond the .001 level of confidence. The critical U for a one-tailed test where $a=.05$ and $n_1=19$, $n_2=20$ is $U \leq 130$. These results are reported in Table 24, Appendix B, page 82. It was concluded that the stable-state strategies adopted by Low Auditory Memory Sequencers under conditions of Payoff-loss are significantly higher than those adopted by Low Auditory Memory Sequencers under conditions of No-payoff.

Further testing, to determine whether or not both sexes adopted a higher strategy under Payoff-loss conditions, revealed that the effect held for female LAMS only. The test on the males' scores yielded a U of 28 which approaches, but does not reach significance, since the critical U value for a one-tailed test when $a=.05$ and $n_1=n_2=10$ is $U \leq 27$. The test for the female LAMS revealed a U of 11.00 which is significant beyond the .001 level. The critical U value for a one-tailed test where $a=.05$ and $n_1=9$ and $n_2=10$ is $U \leq 24$. These results may be found in Table 25, Appendix B, page 83.

A second aspect of hypothesis III requires the comparison of cumulative errors to stable-state (expressed as a cumulative proportion of the first 180 trials) for LAMS under Payoff-loss conditions vs. LAMS performance under No-payoff. The distribution of error scores, with range, median, and mean values for each sub-group of LAMS is reported in Table 12, pages 39 and 40. It was found that across payoff conditions boys had a range of raw error scores from 62 to 98 out of a possible 180, a median of 77.5 and a mean of 78.45. Payoff-loss males' scores exhibited a range from 64 to 87, a median of 77.0, and a mean of 76.8; whereas, No-payoff males' scores ranged from 67 to 100 with a median of 77.0 and a mean of 80.1. Girls' scores, across payoff conditions, showed a range of 51 to 98, a median of 79 and a mean of 78.47. The Payoff-loss females' range was from 51 to 94, with a median of 72 and a mean of 72.50. The No-payoff females (N=9) in comparison had a range of errors from 77 to 98, a median of 84 and a mean of 86.11. The range for the overall Payoff-loss scores was from 51 to 94, the median was 74.0 and the mean was 74.65. In the No-payoff condition scores

TABLE 12

DISTRIBUTION OF PRE-STABLE-STATE (trials 1-180) ERROR
SCORES FOR SUB-GROUPS OF HYPOTHESIS III (LAMS)

Errors to Stable State	Equivalent Proportion	Boys (N=20)	Girls (N=19)	Payoff Condition: Po-Loss (N=20)	Payoff Condition: No-Po (N=19)	Payoff-Loss: Males (N=10)	Payoff-Loss: Females (N=10)	No-Payoff: Males (N=10)	No-Payoff: Females (N=9)
50	.278		X	X			X		
52	.289								
54	.300								
56	.311								
58	.322								
60	.333								
62	.344	X			X			X	
64	.355	X		X		X			
66	.366		X	X			X		
68	.377	XX	XX	XXX	X	X	XX	X	
70	.389	XX	X	XX	X	X	X	X	
72	.400	XX		X	X	X		X	

TABLE 12 (Continued)

Errors to Stable State	Equivalent Proportion	Boys (N=20)	Girls (N=19)	Payoff Condition: Po-Loss (N=20)	Payoff Condition: No-Po (N=19)	Payoff-Loss: Males (N=10)	Payoff-Loss: Females (N=10)	No-Payoff: Males (N=10)	No-Payoff: Females (N=9)
74	.411		XX	XX			XX		
		X			X			X	
76	.422								
		X		X		X			
78	.433	X	X	X	X	X			X
		X	XX	XX	X		XX	X	
80	.445								
		X	XX	X	XX	X			XX
82	.456		X		X				X
		X		X		X			
84	.467		X		X				X
		X		X		X			
86	.478		X		X				X
		XX		X	X	X		X	
88	.489		X		X				X
			X		X				X
90	.500								
92	.511								
94	.522	X	X	X	X		X	X	
		X			X			X	
96	.533								
98	.544	X	X		XX			X	X
Total Errors		1569.000	1491.000	1493.000	1567.000	768.000	725.000	801.000	766.000
Mean Error $\bar{X}$		78.450	78.474	74.650	82.474	76.800	72.500	80.100	85.111
Median Error $(\tilde{X})$		77.500	79.000	74.000	82.000	77.000	72.000	77.000	84.000
Mean Proportion $\bar{p}$		0.408	0.436	0.415	0.459	0.427	0.403	0.445	0.473
Median Proportion $(\tilde{p})$		0.428	0.439	0.411	0.456	0.428	0.400	0.427	0.467

ranged from 62 to 98; the median score was 82 and the mean was 82.47.

The frequency of cumulative errors expressed as proportions of the 180 trials and the cumulated frequencies of those proportions are reported in Table 13, pages 42 and 43.

Before performing a test for differences in error production of LAMS under the separate payoff conditions, a test for sex differences within payoff conditions was made. No significant sex differences obtained when the Kolmogorov-Smirnov two sample test was applied to the data. The maximum discrepancy between the cumulative distributions of males vs. females in the Payoff-loss condition was found to be three and for the No-payoff group recall that the K_D max. was 5. Neither of those obtained values reach the critical value of $K_D \geq 6$ at the .05 level for a two-tailed test when N=10. These results along with the raw error score for each S are reported in Table 26, Appendix B, page 84.

Since no significant sex differences were detected, the scores of males and females were combined within each payoff group in order to allow for a stronger test for differences between payoff groups. The results of this test yield a significant maximum discrepancy, $K_D = 8$, which just reaches the critical value ($K_D \geq 8$) when a = .05 for a one-tailed test with an N of 20. These results may be read in Table 27, Appendix B, page 85.

A further test was applied to the data to determine whether or not the error difference in favour of the Payoff-loss subjects held up for both sexes. The results show that only the female LAMS make significantly fewer errors under Payoff-loss conditions. Males do not. The maximum discrepancy between the cumulative error distributions for females was 8, which is significant at the .01 level for a one-tailed test (with N=10). For males, the maximum discrepancy was only 3. For both tests, the .05 level of critical value was $K_D \geq 6$. These results are reported in Table 28, Appendix B, page 86.

In testing hypothesis III, one final examination was made. From inspecting the data it appeared that not only were LAMS under a Payoff-loss condition adopting higher stable-state strategies and making fewer pre-stable-state errors than No-payoff LAMS, but it also appeared to be the case that their performance exceeded that of HAMS under No-payoff. A Mann-Whitney U one-tailed test, was applied to the data which was found to yield a U of 84.5, significant at the .05 level. (The critical value is $U \leq 138$.) This test result is presented in Table 29, Appendix B, page 87. It was concluded that under conditions of risk, LAMS adopt higher stable-state strategies than do either LAMS or HAMS performing in non-risky, that is, No-payoff circumstances.

The test of hypothesis IV was made under the assumption that the utility factors do not differ from the visual to the auditory situation and vice-versa. It was hypothesized that the Siegel decision model would yield numerically precise predictions of performance in one decision task from performance in the other. The frequency with which

TABLE 13

CUMULATIVE FREQUENCY DISTRIBUTIONS OF PROPORTION OF ERRORS IN PRE-STABLE-STATE TRIALS FOR SUBGROUPS OF HYPOTHESIS III (LAMS)

LAMS Sub-group Cumulated Frequencies								
					Payoff Condition			
Cumulative Error Proportion Interval	Boys (N=20)		Girls (N=19)		Po-Loss (N=20)		No-Po (N=19)	
.281 - .290		0	X	1	X	1		0
		0		1		1		0
.301 - .310		0		1		1		0
		0		1		1		0
.321 - .330		0		1		1		0
		0		1		1		0
.341 - .350	X	1		1		1	X	1
	X	2		1	X	2		1
.361 - .370		2	X	2	X	3		1
		2		2		3		1
.381 - .390	XXX	5	XXX	5	XXXX	7	XX	3
	XX	7	X	6	XX	9	X	4
.401 - .410	X	8		6	X	10		4
	X	9	X	7	X	11	X	5
.421 - .430	X	10	X	8	X	12	X	6
	XX	12	XX	10	XXX	15	X	7
.441 - .450	X	13	XX	12	X	16	XX	9
		13	X	13		16	X	10
.461 - .470	X	14	X	14	X	17	X	11
	X	15	X	15	X	18	X	12
.481 - .490	XX	17	X	16	X	19	XX	14
		17	X	17		19	X	15
.501 - .510		17		17		19		15
		17		17		19		15
.521 - .530	XX	19	X	18	X	20	XX	17
		19		18		20		17
.541 - .550	X	20	X	10		20	XX	19

TABLE 13 (continued)

LAMS Sub-group Cumulated Frequencies

Cumulative Error Proportion Interval	Payoff-Loss				No-Payoff			
	Male (N=10)		Female (N=10)		Male (N=10)		Female (N=9)	
.281 - .290		0	X	1		0		0
		0		1		0		0
.301 - .310		0		1		0		0
		0		1		0		0
.321 - .330		0		1		0		0
		0		1		0		0
.341 - .350		0		1	X	1		0
	X	1		1		1		0
.361 - .370		1	X	2		1		0
		1		2		1		0
.381 - .390	X	2	XXX	5	XX	3		0
	X	3	X	6	X	4		0
.401 - .410	X	4		6		4		0
		4	X	7	X	5		0
.421 - .430	X	5		7		5	X	1
	X	6	XX	9	X	6		1
.441 - .450	X	7		9		6	XX	3
		7		9		6	X	4
.461 - .470	X	8		9		6	X	5
	X	9		9		6	X	6
.481 - .490	X	10		9	X	7	X	7
		10		9		7	X	8
.501 - .510		10		9		7		8
		10		9		7		8
.521 - .530		10	X	10	XX	9		8
		10		10		9		8
.541 - .550		10		10	X	10	X	9

various stable state strategies were adopted by 19 subjects* under the auditory task with $\pi_1 = .75$ and by those same Ss under a $\pi_1 = .65$ in the visual decision task are reported in Table 14, page 45. For the test of the model, an estimate of a, the interaction among all factors of the choice situation which are relevant to the utilities associated with the decision situation, was obtained by means of the equation $a = \frac{2(2p_1 - 1)}{\pi_1 - \pi_2}$ where p_1 is the mean stable state and π_1 equals .65 (the proportion of trials in which the most frequent event occurred in the visual decision situation). The obtained $a_{Vis.}$ value was

$$\frac{2[2(.476) - 1]}{.65 - .35} = \frac{2(.952 - 1.00)}{.30} = .096/.30 = 0.320.$$

This value was substituted in the equation of the model $P_1 = \frac{a}{2k}(k\pi_1 - 1) + \frac{1}{k}$ to obtain the numerical prediction of the strategy that would be adopted by the Ss under the auditory conditions of the decision task. The prediction yielded was: $P_1 = 0.460$. The observed Ss value in the auditory decision task was $P_{aud} = 0.613$. The difference between the predicted and observed stable state is 0.153. This value is larger than one would expect if the utility factors are the same for the two decision tasks and if the model, in fact, predicts. On inspecting the visual decision task data, it was clear that three additional Ss scores are significantly different from a "chance or better" performance. For purposes of obtaining the best estimate of a that is possible from these data, it seemed that recalculating a without benefit of these three additional scores was desirable. Hence a = 0.2933; $P_1 = 0.537$.

Eliminating none of the 20 subjects from the auditory decision task the mean stable-state strategy was observed to be .670, a difference of 0.133 from the predicted value. Eliminating the scores for the four subjects who were eliminated from the visual task as Ss performing under chance, a mean observed SSS of .596 obtains; leaving a discrepancy of only .059 between the predicted and observed values. Applying a Madansky modified Z (Madansky, 1964) to this data, shows the obtained difference to be not significantly different from a chance separation. This, however, does not warrant the conlusion that the model yields a quantitatively precise prediction of the subjects' performance in the auditory decision task from the results of their performance in the visual task. An accurate prediction also would have to be made from the auditory task back to the visual in order to insure that the results could not be accounted for by chance.

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* One female LAMS was eliminated since it appeared, on the basis of inspection, that she was not "playing the game".

TABLE 14

THE DISTRIBUTION OF STABLE-STATE STRATEGIES ADOPTED BY THE SAME SUBJECTS *IN THE AUDITORY (π_1 = .75) AND THE VISUAL DECISION TASK (π_1 = .65)

SSS	Auditory (N=20)	Visual (N=20)	Auditory Boys (N=10)	Auditory Girls (N=10)	Visual Boys (N=10)	Visual Girls (N=10)
.10		F			F	
.15						
.20		n,q			q	n
.25						
.30		l				l
.35						
.40	G,H	r	G,H		r	
.45	C,t	B,G,H,J	t	C	G,H,J	B
.50	I,J,p,s	t,A,C,k,m	I,J,p,s		t	A,C,k,m
.55	k	o,s		k	s	o
.60	D,E	D,E,p		D,E	p	D,E
.65	A			A		
.70	l,q		q	l		
.75	B,m,n	I		B,m,n	I	
.80	F		F			
.85	R		R			
.90						
.95						
1.00	o			o		

Letters A through J identify HAMS; k through t identify LAMS.

CHAPTER IV

DISCUSSION AND CONCLUSIONS

Because of the low level of reliability obtained for the Visual Sequential memory subtest for stability over time ($r = .55$), it was concluded that the sample could not be separated reliably into subjects exhibiting strengths in auditory or visual immediate memory by means of the particular two ITPA subtests administered for that purpose. As a consequence, the original purpose of the study, which was to examine the relationship between sensory functioning of the auditory and visual modalities and strategy behavior in a two-choice uncertain outcome decision situation had to be modified. The alternative, which had been set up at the outset was substituted; namely, a comparison of strategy behavior for high and low auditory subjects as definedby their performance on the Auditory Sequential ITPA subtest of immediate memory.* In turn, the hypotheses were modified to accommodate the single modality focus. All tests, except the quantitative test of the Siegel Model, were run on data gained in an auditory decision task. The hypotheses as modified to test for within-auditory modality strategy differences are stated below:

In the repetitive choice situation -

I. low auditory performers more nearly approximate a pure stable-state strategy in an auditory decision task than do high performers;

II. low auditory performers experience greater series unexpectedness (make more prediction errors) in the pre-stable-state aspect of an auditory decision task than do high auditory performers;

III. low auditory subjects performing under conditions of risk will more nearly approximate the performance of high auditory subjects performing under no-payoff;

IV. low and high auditory subjects combined will exhibit stable-state strategies for which the Siegel Model will yield quantitatively precise predictions.

In testing each hypothesis the data were examined for sex differences within the High and within the Low Auditory Sequencers before combining Ss across sex, for a stronger test of the individual hypotheses. In general, the results indicate that high and low auditory performers, as identified on the Auditory Sequential subtest of the ITPA, do not differ in their rate of learning nor in the level of performance they adopt in the "stable-state" phase of a two-choice auditory decision task. Cumulative error and level of stable-state strategy both change favourably when subjects are required to function under conditions of risk.

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* In the result section (Chapter III) high and low auditory groups were referred to as "HAMS" and "LAMS", respectively.

The results from the test of the first hypothesis, comparing stable-state strategies for High and Low sequencers, indicate that there is no significant difference in the level of performance adopted by the two groups in the final block of two hundred trials. The trend in the data favours the performance of the High Auditory Sequencers which opposes the prediction made from the Siegel Model. Referring to Figure 1, page 36 of this text, it can be seen that performance is fairly level for both sexes in the Low groups for the final 40 trials. High females' performance tends to drop while High males tend toward adopting higher strategies. The fact that Low girls stabilize at a level not much better than chance, somewhere in the vicinity of 150 trials, taken in conjuction with the fact that none of the No-payoff groups' final block strategy reaches the matching strategy level (i.e., $p_1 = .75$, when $\pi_1 = .75$) appears to be fairly strong evidence that the original theorizing is not supported by the data for this sample. Recall that it was argued from the model that any factors which cognitively enrich the decision situation would reduce the utility of variability and all else being equal, particularly the utility of being correct being held constant, the tendency for a subject to adopt a pure strategy would increase. It was further argued that an auditory decision task should be more enriched (actually, more demanding) cognitively for an individual who is identified as a Low auditory sequencer than for one who is identified as a high performer on the same dimension. Various hypotheses might be entertained as tentative explanations for the obtained results. The most inviting is the possibility that the subjects were not motivated; or alternatively, the groups were equally unmotivated so that what was learned about the distribution in the earlier trials remains unmanifest. We will return to this explanatory possibility in relation to discussing the results of the test of hypothesis III in which Low Auditory Ss performed under conditions of extrinsic reinforcement. Before accepting this, or other attempts to account for these results, one must entertain the possibility that (1) the immediate memory sequencing involved in the Auditory Sequential ITPA subtest plays no part in, or is in no way related to the operations or types of operations involved in a probabilistic decision task of the monotonous kind used in the study; and/or (2) the task in no way represents a low b situation (i.e., one in which there is low utility of choice variability) for Low Sequencers or a high b situation for High Sequencers. Looking at the results of the test of the second hypothesis adds some information. The apparent difference between High and Low Sequencers with regard to the amount of series unexpectedness they express within the first 180 trials in an auditory sequence, can be attributed to the difference between the amounts expressed by High vs. Low female Auditory Sequencers. High and Low males were, for all practical purposes, identical in the number of errors they made in their predictions. Low females stabilized earlier in the series and also made a significantly high median number of prediction errors than any other group. This appears to be a substantial difference which indicates that sex and auditory strength interact to produce these results. On the average, to be a Low Auditory Sequencer does not necessarily mean that one would commit more learning errors in a probability learning task unless one were a female. Similarly, to be a High Auditory Sequencer does not imply a relatively low proportion of prediction errors in learning the probabilities associated with a

series of events, unless one is a female. Low subjects, whether boys or girls, tend to stabilize earlier in the series than do High subjects. These results may indicate that high monotony plus high cognitive demand produces a tendency to stick with a strategy even though it isn't working very well. That is, the subject may be "giving up" any attempt to improve. Perhaps girl Ss become stereotyped in their behavior and adopt a lose-stay strategy in the face of performing in a modality in which they are not proficient. Such a tendency to "give up" could conceivably be intensified for these high error Ss if they learn of the random nature of the event distribution more readily, but are not "comfortable" enough in the auditory mode to shift to a pure strategy. The question remains as to whether this performance is a function of low motivation or if, in fact, low female Auditory Sequencers somehow have a unique capacity or upper limit for the task under consideration. The results from the test of hypothesis III suggest it is more defensibly the former. Another possibility, of course, is that the nature of the task more nearly fits activities identified as "fitting" the male sex role in our culture.

It was found in the test of hypothesis III that Low Auditory Memory Sequencers of either sex, when required to make their choices under conditions of monetary payoff for being correct and monetary loss for predicting incorrectly, not only surpass Low Ss who have not been so rewarded, but they also significantly exceed unrewarded High Auditory Sequencers in their "stable-state" performance. Among the low subjects, the significant difference in favour of the payoff-loss subjects apparently was contributed by the females. It is important to note however, that the difference which exists within the Low males' performance also is in favour of the payoff-loss group and approaches significance at the 5% level. Payoff-loss subjects make fewer errors than subjects performing under no extrinsic reward, but this too is a function only of the females' performance. The data for this sample does not support the notion that males under the different payoff conditions commit different proportions of errors across the trials to the final trial block. Again if one refers to Figure 1, page 36, it is interesting to note that only Low female Auditory Memory Sequencers functioning under payoff-loss conditions clearly adopt a pure strategy; they do so in the vicinity of the 150th trial and maintain that level for the final 25% of the trials. Low males and females under no-payoff exhibit similar patterns; with the females tending more definitely toward stabilizing and the males tending more toward a matching strategy. The performance of the Low payoff-loss males is remarkable however, in that it is far from stabilizing and exhibits an obvious increase in slope in the final quarter of the task. Payoff-loss females also continue to select the more frequent event at an increasing rate. All groups show a drop in performance in the third from the final trial block (trials 141-160).

The contrast of the performance of Low Auditory Memory Sequencers under the two payoff conditions show some noteworthy phenomena: apparently only Low females clearly adopt a stable strategy, and they do so only under no-payoff conditions, at a point roughly three-fourths of the way through the task, the stable-state strategy of Low females under conditions of risk more nearly approximates a pure strategy than does that of Low males under either payoff condition, or that of High

males or females under the no-payoff condition; the performance of Low females suggest that it would have been desirable, and perhaps even essential, for an adequate test of the main hypothesis to have required High Ss to perform under conditions of payoff-loss to ensure adequate motivation (recall that it was reasoned that reinforcement might mask the natural tendencies of low and high Ss performing in such a simple task); the performance of those Ss who did stabilize indicates that the theorizing was out of line with regard to expecting differences in the "learning" aspect versus the applicational or "performance" aspect of the curve; the results also clearly show the arbitrary character of selecting the last trial block as the stable state.

The literature on decision making in a two-choice uncertain outcome situation usually involves 100 trials or less and an arbitrary stable state is defined, usually as the last block of 20 trials (Weir, 1964; Weir, 1967; Stevenson and Odom, 1964; Siegel and Andrews, 1962; Glim, 1968). Whereas, similar studies involving adult subjects reveal the emergence of a natural asymptote at the 200 trial point or beyond. Glim (1968) raises a question as to the likelihood that rate of learning in this type of task for children might exceed that of adults. The fact that Low Auditory females in the present study appear to stabilize around the 150th trial and at a level approximating a matching strategy when under reinforcing conditions might suggest that at least they have learned the probability distribution of the events. To draw such a conclusion would require that the design include a shift in π_1 values mid-way through the task with a comparable shift occurring in the Ss' strategy. Whether or not they learned that the occurrence of events is random is impossible to say. Perhaps "types" of children, those who don't stabilize and those who stabilize at less than a pure strategy, are responding to utilities other than the utility of being correct. --On the other hand, perhaps low auditory performers functioning in an auditory decision task of this sort are not able to grasp the notion that the series is random and do, in fact, give up without ever seeing the essential connection between a pure strategy and being right most of the time. Glim makes the point that unless the utility of a correct choice is enhanced through reinforcement (in addition to knowledge of results) any number of other utilities operating in the situation may take precedence and thereby interfere with the tendency to stabilize. It seems to this investigator that responding in terms of other utilities need not interfere with the tendency to stabilize, but is likely to interfere with the tendency to stabilize at a high (pure stratogy) level.

The Estes probability learning model fails to explain the shift toward a pure strategy demonstrated in the present data under the payoff-loss condition and further, refers to the adoption of a matching strategy as "irrational". The Siegel Model on the other hand, offers an explanation in terms of the utility of variability and implies that the subject is rational in pursuing whatever has utility for him and which need not necessarily amount to being "correct". There are too many unknowns in this study to allow one to draw firm conclusions regarding what produced the observed effect. The modified design was inadequate to the task at hand. The fact remains, however, that Low Auditory Sequencers when required to predict outcome in an auditory

task under risk conditions, do better than when performing under low- or no-risk conditions, but still fail to adopt a pure strategy. Three possible tentative explanations of these results come to the fore. There is the possibility that Low Auditory Memory Sequencers are limited in their auditory skills and are (1) not confident (because of a past history of failure) that the perceived randomness is veridical, or (2) that the nature of the task (monotonous and demanding auditory skill) discourages sustained effort to learn the distribution plus its random nature, and/or (3) the task simply is too difficult for Low Auditory Sequencers and the performance in the decision task is a valid reflection of the prediction one would make from the ITPA Subtest performance. This third explanation reasonably can be entertained only for the stabilized Low groups; all other groups presumably still are shifting strategies by the time they reach the arbitrary trial block designated the stable state.

The data of hypothesis IV in addition to lending quantitative support to the Siegel Model, show that the subjects (low and high Auditory Sequencers) are utilizing probability principles in making their predictions. This fact is reflected in the increase in level of strategy adopted in the separate stable states; subjects performing in the auditory task (where $\pi_1 = .75$) adopt a higher strategy in the stable state for that task than they do when performing in the visual task, where $\pi_1 = .65$. It is interesting to note that the trend in the stable-state mean strategies for High vs. Low Auditory Sequencers supports the original theorizing. That is, Low Sequencers adopt higher stable state strategies than do High Sequencers. The difference is not significant, however, and the fact that Ss only performed for 160 trials plus the possibility of the effect being a sampling artefact makes the comparison more or less meaningless. Subjects performing in the visual task, on the average perform at chance level or below. Seventy-five percent of the subjects adopted a strategy in the auditory task at least as high as they did in the visual. (Sixty-five percent actually adopted a higher strategy.) Despite the fact that the order in which subjects underwent the two tasks was randomized, performance in the visual task was less adequate for all groups. This information may make the assumption under which this test was carried out, namely, that the auditory and visual decision tasks do not differ with regard to utility factors, -- suspect. Another possibility, however, is that there is a reliance on the auditory modality regardless of whether the cues are auditory or visual. When cues are presented to the visual modality, the child provides himself with a repetition of the information to the auditory modality via vocalization of the visual cues. This interpretation would be consistent with the results in the data for hypothesis IV, except for the sub-groups of female Low Auditory Memory Sequencers who exhibited the highest stable-state strategy of all groups in the auditory task and the lowest stable-state strategy of all the groups in the visual task. The other groups: High males, Low males, High females, maintain the same order in both the visual and auditory tasks.

The concern for the role of input modality in learning is neither new nor trivial. According to Freud (1953) Charcot was the first to approach learning through a modality typology. He (Charcot) apparently spoke of "audile", "visile", and "tactile" learners. Work along the

lines of modality preference in learning has been on the increase since the 1930's, and probably has its most advanced formulation in the work of Wepman (1958, 1968), Bannatyne (1966), Kirk, McCarthy, and Kirk (1968), Paraskevopoulos and Kirk (1969) and others. According to Wepman the differential use of input pathways or the modality-bound nature of children's learning is receiving substantial support. In some of his own factor analytic work, Wepman, et al. found strong evidence for an oral-auditory factor and a separate factor for 'oral response to visual stimulus' factor. He further maintains that for any of the modality deficits no stimulus deprivation factors could be found. Other recent literature, Siegel and Andrews (1963), Weir (1967), Stevenson and Odom (1964), Bannetyne (1968), and Morency (1968) have found developmentsl factors related to age, sex, and neurologic development to be of significance in both learning and decision processes involving discrimination and memory. With regard to age factors, the findings seem to suggest a shift in reliance from the visual modality to the auditory with advancing age. This may account for the d decreasing reliability of the Visual Sequencing memory subtest of the ITPA (Paraskevopoulos and Kirk, 1969). Wepman (1968) maintains however, that the two major modalities reach a stage of equalization of function by age nine and that the modality showing the most rapid development, indicates the child's predelection. He further hypothesizes that the "auditory" child is one for whom the auditory pathway matures first, and that the use of this pathway aids in it development. The auditory child may, according to Wepman, have a visual function which is either rapid or slow. For future research one might entertain the notion that the females' auditory performance in this study may suggest some sort of interaction of sex, and auditory-visual development. According to Wepman and others in the field, there is ample agreement that auditory functioning involves at least discrimination, memory, and sequencing ability. Some of the results of the present study may be attributable to the fact that there may have been an (undefined) mismatch in the weighting of the operations involved. The Auditory Sequential subtest of the ITPA is regarded by the test composers (to be) a test of immediate memory; to what degree this factor (immediate memory), discrimination, and sequencing are involved is difficult to say, though they all appear to be. Similarly the decision task has been assumed to involve memory, sequencing, and discrimination skills (Weir, 1967); but the weighting of these variables, required in accurate prediction skills, is unknown. The ideal course for future investigation would be to experiment with a decision task and an independent measure, for which the content validity were known.

The performance of the age group used in this study has been studied fairly closely by Stevenson and Zigler (1958) and by Weir (1967) in contrast to other age groups. Some general findings have emerged that seem relevant to the present results. Stevenson and Zigler found that children aged seven to eleven started out in a three choice uncertain outcome situation at a chance level of performance and never got much beyond it. Also, in studying the strategies adopted, they found that this age group adopted certain "favorite" strategies and would not abandon them when reward wasn't consistently forthcoming. It was hypothesized that children this age, though "sophisticated in their expectancies and strategies they adopted"

were unable to use the information available to them in the situation and would repeatedly return to the same strategy producing a stereotyped pattern of response. Weir (1967) hypothesized that the stereotyped pattern was due to this age group's inability to remember what had happened the last time they tried a particular strategy. Weir's suspicions were confirmed when he provided the group with a memory aid: their strategies involved fewer repetitions and they chose the payoff event more frequently than when left to rely on their own memories. Weir et al. also found different methods of manipulating motivation and determined that when high valued incentives are available, subjects concentrate on maximizing gain while penalty conditions enhance the subjects tendency to minimize loss. --Each taken separately produces higher level strategies but the former invites seeking a better solution; the latter, to avoid losing and stick with the winner. Siegel and Andrews found that there is a steady improvement in the stable-state strategy as a function of no-payoff, payoff, and payoff-loss. In other words, combining the two incentive conditions produced an increased tendency to select the more frequent event through being paid off for being correct plus being punished for being incorrect. The results of the present study in general produced the same effect and it is most obvious in its effect on the Low Male Auditory group. This suggests that for further research one might hypothesize that the two types of incentive, payoff and payoff-loss, may interact with sex in low Auditory memory sequencers to produce differential effects. It could be that efficient probability learning in males, particularly of the monotonous sort, in our culture rests on making the task worthwhile through increased payoff -- not to mention the sociologic possibility that boys are more responsive (in the required direction) to the punitive, authoritarian discipline (Bronfennbrenner, 1961).

CHAPTER V

SUMMARY

The purpose of this study was to investigate decision behavior exhibited by elementary school-aged children in a simple laboratory decision task. An effort was made to separate children into "auditory" and "visual" subjects on the basis of their performance on two immediate memory sub-tests from the revised (1968) ITPA. The population sampled was children, aged seven years to eight years and three months, attending the five summer school centers in School District 4J of the Eugene Public School System. The original subject pool consisted of 283 Ss for whom parental permission to participate was obtained by mail. Test-retest data were obtained for 252 Ss in all. On the basis of the first administration of the Auditory and Visual Sequential ITPA sub-tests, children who obtained Language Age scores which were discrepant by 18 months were regarded as having a sensory sequencing strength in favour of the modality of the higher score. In all, 120 subjects were so identified. Test-retest data yielded a Pearson Product-Moment Correlation coefficient of .55 for the Visual Sequential sub-test and of .91 for the Auditory Sequential sub-test. Since the correlation for the Visual test did not reach the specified level of .85, the intended comparison of "auditory" vs. "visual" subjects could not be completed. Instead, a comparison was made of within Auditory Strength (on high vs. low performers') decision strategies. Subjects were randomly selected from the pool of subjects who underwent the first test administration of the ITPA Auditory Sequential test. In all, 247 subjects made up this group, 136 males and 116 females. High and Low Auditory Ss were identified as Ss receiving scores on the Auditory Sequential sub-test which were one standard deviation, respectively above and below (the confidence interval for) the mean of the relevant age group. Actually, in order to insure an adequate number of replacements some Ss were drawn at somewhat less than one S.D. beyond the mean.

From the randomly drawn Ss, 80 were assigned in random order to the four hypotheses. Two decision tasks were involved in the study and subjects were tested individually. In either task, Ss were required to predict (guess) whether one of two events would occur. The events were either a pulsing or a steady stimulus. The apparatus used to present the events was an electronically timed "decision" machine. All tests, ITPA and the decision tasks, were administered by graduate students at the University of Oregon. In both decision tasks, the events were randomly presented with $_1$ set at .75 in the auditory task and at .65 in the visual. The Siegel Math Model of Decision and Choice was used to generate the hypotheses. Each S underwent 200 trials or 160 trials per task depending upon to which hypotheses he was assigned. The order in which either of the two events occurred from trial to trial was random with two restrictions: (1) in no instance was the more frequent event allowed to occur more than six times in succession, and (2) the event probability distribution was maintained within each trial block. The stable-state was arbitrarily designated as the final block of 20

trials. Which event of the two (pulsing or steady) became the more frequent event was determined through a coin toss procedure with the stipulation that equal numbers of high and low auditory performers experience each.

It was hypothesized that subjects would perform differently in the pre-stable-state aspect of the test than in the stable state. That is, it was predicted that High Auditory performers as identified on the Auditory Sequential test of the ITPA would make fewer errors while "learning the task", but would be more responsive to the monotony of the task and would therefore be more apt to vary their choices in the stable-state than would the Low Auditory Sequencers. High Auditory performers should therefore (it was reasoned) reach an asymptote earlier in the series than Low Ss, and should stabilize at a level beyond a matching strategy but somewhere short of a pure strategy. Low Auditory Ss were expected to make more pre-stable-state errors but stabilize at a higher level. The results showed that significant differences exist between High and Low Auditory Ss only for females and only in error scores.

It was further hypothesized that if Low Auditory subjects were required to perform under monetary payoff-loss conditions they would improve their performance both by reducing the number of pre-stable-state errors made and by adopting a higher (more nearly pure) stable-state strategy. These results were confirmed. In addition, these Low Auditory performers under payoff-loss when compared with High Auditory performers under no-payoff, exceeded the latter group in their stable-state strategy level. It was concluded that the interpretation of these results was considerably limited by the fact that no High Auditory Ss had been required to perform under Payoff-loss conditions.

Finally, a group of subjects were required to be their own match in an auditory and visual decision task. The most frequent event occurrence was set to occur on 75% of the trials (N=200) in the auditory task and 65% of the trials in the visual task. It was found that the Siegel Model yielded accurate quantitative predictions of subject performance in the auditory task from their performance in the visual task. From inspection of the data it was concluded that Ss were using probability principles in making their predictions.

The results were discussed in light of recent sensory modality literature and children's functioning in probability decision tasks.

It is concluded that the main limitation of the study arose in the lack of reliability of the instruments selected to separate the sample into modality groups and that the main value of the study, therefore, is heuristic.

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APPENDIX A

LETTER TO PARENTS

Dear Mr. and Mrs. _____________:

____________________ has been chosen to participate in a research study supported by the U.S. Office of Education and the University of Oregon. The Eugene Public Schools are aware of this study and of its possible benefit to education. The purpose of the study is to determine if (some) children learn what they <u>hear</u> more easily and efficiently (for example, new information the teacher tells them) while others learn what they <u>see</u> (for example, new information they read for themselves) more easily and efficiently. In addition, the study will examine whether or not children who differ in this way also differ in the way they make decisions.

The purpose of this letter is to request your permission for _____________ to participate in our study. Each child who participates will undergo less than two hours of testing in all, at least half of the children in the study will be required to participate for thirty (30) minutes only. At this point, it is estimated that the majority of the children will be tested in the afternoon. We anticipate that your child would be tested twice between June 19th and July 2nd and once between July 2nd and July 18th. In the event that your child is scheduled for testing in the afternoon on any of the three testing periods, the project staff will be happy to choose a time that is convenient to you and will assume all responsibility for transportation (expense and safety) to and from the testing center. In no case will we transport a child directly from summer school to the testing center, but we will always arrange transportation directly from and to the home. We realize that some parents may wish to transport their own child to and from the center. Such an arrangement is perfectly acceptable.

We have enclosed a permission slip and self-addressed envelope. We would appreciate it if you would check the appropriate answer squares, sign the slip, and return it to our office by June ___, 1969. In the meantime, the project director will contact you by phone to provide an opportunity for you to ask any questions you may have regarding the study and to establish permission to test your child.

Please understand that the children who participate in this study will be making a very important contribution to the field of education. A contribution which we believe will lead to a better understanding of how children learn and consequently to improve curriculum planning in the primary grades.

Your consideration and cooperation are sincerely appreciated.

Helen Simmons
Project Director

PERMISSION SLIP

Please return to H. Simmons
1609 Agate Street
University of Oregon
Eugene, Oregon 97403

If permission is granted, the first testing of your child is planned for ______________________. Afternoon testings will be confirmed by telephone.

If you further participation is required please check which of the following afternoons would be suitable.

Monday	___	Thursday	___
Tuesday	___	Friday	___
Wednesday	___	Saturday	___
Early Afternoon (I:00 p.m. to 3:00p.m.)	___	Late Afternoon (3:00 p.m. to 4:30 p.m.)	___

We grant permission for ______________to participate in your study of Auditory and Visual Decision-Making of Young Children as outlined in your accompanying letter.

Mr.
Signed or __________________
Mrs.

PHONE CALLS TO PARENTS

I'm ________________, calling for Helen Simmons about the letter we sent you regarding your child's participation in our research study. Have you received this letter?

Do you have any questions regarding the study or the letter?

(IF NOT) Are you willing to let your child participate?

(IF NO) (And if child is in the afternoon group) If it is possible to test your child in the morning at school, would you be willing to let ________________ participate?

(IF YES) Is the time we have set up suitable?

(IF NO) Is any other time the same afternoon possible?

(IF NO) Then could you specify some afternoon that would be convenient for you and we will call you back later to arrange a time.

The testing itself will only take 1/2 hour. We have your child scheduled for ________________. We plan to pick ____________ up in the University car at ______________ and will have (him, her) back home by ______________.*

Would you please give us your child's birthdate?

If your child is in the group of children we plan to test twice, and if he is in one of the afternoon groups, we will call you again to confirm a time for testing.

---

* Times of pickup and delivery corresponding to testing times:

1:00	-	2:15	1:30 - 2:00
1:30	-	2:45	2:00 - 2:30
2:00	-	3:15	2:30 - 3:00
2:30	-	3:45	3:00 - 3:30
3:00	-	4:15	3:30 - 4:00
3:30	-	4:45	4:00 - 4:30

TABLE 15

MEDIAN INTERCORRELATIONS FOR THE AUDITORY AND VISUAL SEQUENTIAL SUBTESTS OF THE ITPA AND FOR THE ITPA COMPOSITE FOR TWO AGE GROUPS OF AVERAGE INTELLIGENCE*

	Age Group					
	6-7/7-1 (N=124)			7-7/8-1 (N=123)		
Test	Aud. Seq.	Vis. Seq.	Comp.	Aud. Seq.	Vis. Seq.	Comp.
Aud.	—	.15	.26	—	.04	.24
Vis.		—	.24		—	.25
Comp.			—			—

*After Kirk, Mc Carthy and Kirk (1968)

TABLE 16

TEST-RETEST DATA FOR THE VISUAL AND AUDITORY SEQUENTIAL (MEMORY) SUBTESTS OF THE ITPA (N=120)

Age Group 7-0/7-3	Code #	Raw Scores V_1	V_2	Raw Scores A_1	A_2	PLA Differences D_1	D_2
1	1	19	21	33	27	*A 21	V 9
2	2	19	20	37	30	A 33	A 6
3	3	24	22	27	25	V 24	V 21
4	5	23	24	26	30	V 21	V 15
5	6	19	35	35	35	*A 27	V 51
6	9	25	24	18	24	V 54	V 33
7	10	23	22	24	28	V 27	V 12
8	14	22	27	45	43	A 33	A 3
9	15	16	25	35	36	*A 45	V 3
10	18	20	19	18	21	V 27	V 12
11	19	25	18	30	32	*V 20	A 24
12	20	25	30	14	14	V 66	V 91
13	21	20	24	13	12	V 42	V 63
14	23	18	14	37	42	A 39	A 75

Test-retest data shows shift from discrepancy favoring one modality to one favoring the other.

TABLE 16 (continued)

Age Group	Code #	Raw Scores V_1	V_2	Raw Scores A_1	A_2	PLA Differences D_1	D_2
7-0/7-3							
15	24	19	19	18	17	V 21	V 24
16	26	21	23	21	17	V 24	V 45
17	31	15	23	32	34	A 42	A 3
18	32	28	24	26	33	V 51	V 6
19	33	19	19	33	39	A 21	A 39
7-4/7-7							
20	40	14	17	29	30	A 39	A 24
21	41	16	17	32	25	A 36	A 12
22	42	23	26	20	25	V 36	V 39
23	46	34	41	42	46	V 30	V ?
24	47	17	21	27	27	*A 18	V 3
25	48	20	22	16	19	V 27	V 33
26	49	14	17	25	26	A 27	A 15
27	50	20	21	18	21	V 21	V 21
28	59	15	20	28	26	A 33	0
29	62	25	22	25	27	V 33	V 9
30	63	22	23	16	18	V 39	V 39
31	64	27	28	23	19	V 48	V 66
32	66	18	21	51	51	A 69	A 54
33	69	23	24	26	30	V 18	V 57

TABLE 16 (continued)

Age Group 7-4/7-7	Code #	Raw Scores V_1	V_2	Raw Scores A_1	A_2	PLA Differences D_1	D_2
34	70	25	22	23	23	V 39	V 21
35	75	8	17	42	36	A 102	A 42
36	79	17	20	28	28	A 21	A 6
37	81	22	20	23	31	V 21	A 12
38	82	19	21	17	18	V 21	V 27
39	83	24	21	25	25	V 27	V 9
40	85	16	26	25	24	A 18	V 42
41	90	16	26	27	30	A 24	V 27
42	91	21	18	36	37	A 21	A 39
43	96	24	27	23	25	V 33	V 42
44	97	24	18	25	31	V 27	A 21
45	99	16	22	31	37	A 33	A 18
46	103	24	21	16	19	V 51	V 27
47	104	23	21	25	35	V 21	A 18
48	106	15	21	27	32	A 30	A 9
49	107	27	42	28	40	V 33	V ?
50	108	25	21	25	29	V 33	A 3
51	109	21	21	15	10	V 36	V 48
52	110	25	21	30	26	V 21	V 6
53	111	26	18	19	17	V 57	V 15

TABLE 16 (continued)

Age Group	Code #	Raw Scores V_1	V_2	Raw Scores A_1	A_2	PLA Differences D_1	D_2
7-4/7-7							
54	112	23	27	42	44	A 21	A 6
55	114	21	27	47	48	A 45	A 15
56	115	22	20	38	47	A 18	A 51
57	116	22	22	24	28	V 18	V 6
58	117	12	18	18	22	A 21	V 3
59	119	17	26	29	31	A 24	V 24
60	121	24	22	19	18	V 45	V 33
61	122	17	19	14	15	V 18	V 27
62	123	34	24	30	29	V 60	V 15
7-8/7-11							
63	137	26	29	24	22	V 39	V 60
64	139	19	27	42	42	A 42	A 3
65	140	26	25	25	25	V 36	V 30
66	141	18	23	34	45	A 30	A 27
67	142	21	17	44	44	A 36	A 57
68	143	25	29	16	20	V 51	V 63
69	145	25	28	23	23	V 36	V 51
70	148	23	15	43	44	A 24	A 66
71	149	22	20	24	21	V 18	V 15
72	150	24	24	17	18	V 45	V 45

TABLE 16 (continued)

Age Group 7-8/7-11	Code #	Raw Scores V_1	V_2	Raw Scores A_1	A_2	PLA Differences D_1	D_2
73	154	25	28	26	31	V 27	V 30
74	157	13	14	29	33	A 45	A 48
75	158	23	31	45	50	A 27	0
76	159	23	22	26	28	V 18	V 6
77	150	21	22	14	16	V 36	V 36
78	161	33	39	40	48	V 27	V 45
79	162	21	18	16	15	V 30	V 18
80	166	11	18	26	25	A 45	A 6
81	167	28	24	28	30	V 36	V 15
82	169	18	19	34	28	A 30	A 9
83	170	23	24	18	21	V 39	V 36
84	174	22	19	19	19	V 30	V 15
85	180	25	23	27	28	V 24	V 12
86	182	18	19	31	30	A 21	A 12
87	183	16	21	28	26	A 27	V 6
88	184	22	24	37	42	A 18	A 15
89	190	16	21	31	45	A 33	A 39
90	191	19	22	32	30	A 18	V 3
91	194	21	17	39	33	A 27	A 33
92	195	17	17	30	30	A 24	A 24

TABLE 16 (continued)

Age Group 7-8/7-11	Code #	Raw Scores V_1	V_2	Raw Scores A_1	A_2	PLA Differences D_1	D_2
93	198	18	21	42	36	A 48	A 21
94	203	24	21	27	30	V 21	A 3
95	204	19	30	33	35	A 21	V 27
96	206	14	16	24	33	A 24	A 39
97	215	16	23	25	27	A 18	V 15
98	219	20	22	20	20	V 18	V 27
99	220	26	18	24	27	V 39	A 12
8-0/8-3							
100	231	26	30	19	28	V 45	V 45
101	233	26	28	19	20	V 45	V 54
102	234	25	22	21	23	V 39	V 18
103	236	32	39	24	26	V 66	V 96
104	238	22	20	38	37	A 18	A 27
105	239	21	26	36	38	A 21	0
106	241	22	26	42	43	A 27	A 9
107	246	20	24	40	44	A 33	A 18
108	249	20	23	16	22	V 24	V 27
109	253	21	20	12	13	V 36	V 33
110	256	20	18	47	42	A 45	A 48
111	258	26	26	29	29	V 21	V 21

TABLE 16 (continued)

Age Group 8-0/8-3	Code #	Raw Scores V_1	V_2	Raw Scores A_1	A_2	PLA Differences D_1	D_2
112	265	27	29	28	35	V 30	V 21
113	266	15	18	28	25	A 30	A 6
114	267	25	33	29	29	V 18	V 42
115	269	18	19	29	31	A 18	A 15
116	270	23	20	43	47	A 21	A 45
117	272	16	20	49	50	A 69	A 51
118	276	23	27	40	48	A 18	A 15
119	277	19	25	35	39	A 27	A 9
120	278	27	25	19	18	V 51	V 45

TABLE 17

PSYCHOLINGUISTIC AGE* AND IDENTIFYING INFORMATION
FOR EXPERIMENTAL Ss BY HYPOTHESIS

HIGH FEMALES

Code #	Summer School	Regular School	Time Tested AM	Time Tested PM	Tester	Age in Months	A-MS Lang Age	
2	Ad	Adams	AM		M	87	117	H 1 & 2
15	Sc	Spring Creek	AM		S	86	111	
66	H	Harris		PM	S	88	144	
115	Wk	Eugene Jr. Academy	AM		S	90	114	
142	H	Harris		PM	D	92	123	
152	H	Condon	AM		S	95	108	
184	Sc	Santa Clara		PM	A	94	111	
194	Sl	Silver Lea	AM		M	92	114	
202	Wk	St. Paul		PM	M	93	111	
246	D	Fox Hollow		PM	S	96	114	
						$\bar{X}$=91.3	$\bar{X}$=116.7	
6	H	Harris		PM	S	86	111	H 4
114	Wk	Washington	AM		D	89	135	
165	D	Dunn		PM	S	93	109	
178	Sc	Santa Clara	AM		S	94	117	
270	Wk	St. Paul		PM	M	99	117	
						$\bar{X}$=46.1	$\bar{X}$=117.6	

$\Sigma(\Sigma x)$ High Females = 1755 (N=15) $\bar{X}$=117.0

* Psycholinguistic Age = Language Age.

TABLE 17 (continued)

HIGH MALES

Code #	Summer School	Regular School	Time Tested AM	Time Tested PM	Tester	Age in Months	A-MS Lang Age	
8	D	St. Mary's		PM	S	91	103	
45	Ad	Willard		PM	M	90	123	H
57	Ad	Adams		PM	A	89	111	C
91	Sc	Santa Clara		PM	S	89	111	
153	Ad	Westmoreland		PM	A	94	114	2
158	H	Condon		PM	S	95	126	
161	D	Willard		PM	A	92	117	
176	Sc	Aubrey Park	AM		D	92	108	
272	Wk	Washington		PM	S	96	129	
279	Sc	Santa Clara		PM	A	99	114	
						$\bar{X}$=92.6	$\bar{X}$=116.1	
14	D	Edgewood	AM		M	86	135	H
139	Sl	Howard		PM	S	92	120	4
163	D	Edgewood		PM	A	93	114	
198	Wk	Washington	AM		D	95	120	
205	Wk	Willakenzie		PM	S	95	117	
						$\bar{X}$=92.5	$\bar{X}$=121.2	

$\Sigma(\Sigma x)$ High Males = 1770 (N=15) $\bar{X}$=118.0

TABLE 17 (continued)

LOW MALES

Code #	Summer School	Regular School	Time Tested AM	Time Tested PM	Tester	Age in Months	A-MS Lang Age
							H 1 & 2
7	D	Dunn	AM		A	87	57
52	H	Edison	AM		D	91	66
105	Wk	Washington	AM		S	89	63
121	D	Dunn		PM	D	89	63
143	Ad	Adams	AM		M	94	57
146	H	Harris	AM		D	95	60
175	D	Edgewood	AM		M	94	63
242	D	Dunn	AM		A	98	66
251	D	Dunn	AM		M	96	66
278	D	Dunn		PM	D	97	63
						$\bar{X}$=93.0	$\bar{X}$=62.4
							H 4
21	Sl	Howard	AM		A	85	48
24	Wk	Willakenzie	AM		S	85	63
102	Sl	Silver Lea		PM	M	88	63
192	Sl	Silver Lea	AM		A	95	63
261	Sl	River Road		PM	A	96	63
						$\bar{X}$=89.5	$\bar{X}$=60.0
							H 3
9	H	Harris		PM	M	87	63
13	D	Dunn		PM	M	87	66
54	Ad	St. Mary's	AM		A	91	60
56	Ad	Willard		PM	A	91	63
82	H	Harris	AM		D	90	60
111	Wk	Washington		PM	D	88	63
162	D	Dunn		PM	A	93	57
233	Ad	St. Mary's		PM	S	98	63
249	D	Edgewood		PM	M	97	57
271	Wk	Meadowlark		PM	M	97	66
						$\bar{X}$=91.9	$\bar{X}$=61.8

$\Sigma(\Sigma x)$ Low Males = 1542 (N=25) $\bar{X}$=61.7

TABLE 17 (continued)

LOW FEMALES

Code #	Summer School	Regular School	Time Tested AM	Time Tested PM	Tester	Age in Months	A-MS Lang Age	
63	Ad	Adams		PM	A	88	57	H 1 & 2
68	D	Dunn	AM		A	89	63	
88	Sc	Aubrey Park		PM	M	91	60	
160	D	Dunn	AM		A	95	51	
174	H	Fox Hollow	AM		S	92	63	
187	Sc	Aubrey Park	AM		D	94	57	
214	Wk	Coburg	AM		S	93	63	
245	D	Dunn		PM	A	96	78	
255	Sc	Santa Clara		PM	A	96	60	
274	Wk	Coburg	AM		S	96	66	
						$\bar{X}$=93.0	$\bar{X}$=61.8	
10	D	Dunn		PM	S	89	78	H 4
48	H	Harris		PM	D	88	57	
103	Sl	Silver Lea	AM		M	90	57	
170	D	Dunn		PM	M	93	60	
209	Wk	Washington	AM		S	94	63	
						$\bar{X}$=90.8	$\bar{X}$=63.0	
20	Sl	Lincoln	AM		A	87	51	H 3
42	Ad	St. Mary's		PM	M	88	66	
43	Ad	St. Mary's		PM	M	88	60	
50	H	Harris	AM		D	89	63	
71	D	Dunn		PM	A	88	57	
76	H	Harris	AM		D	88	63	
219	Ad	Ida Patterson		PM	D	95	66	
231	H	Harris		PM	A	96	63	
254	Sc	Santa Clara		PM	A	98	72	
262	Sl	Howard	AM		A	98	78	
						$\bar{X}$=91.5	$\bar{X}$=63.9	

$\Sigma(\Sigma x)$ Low Females = 1572 (N=25) $\bar{X}$=62.9

APPENDIX B

TABLE 18

MANN-WHITNEY U TEST FOR DIFFERENCES IN THE SUM OF RANKS ASSIGNED TO STABLE-STATE STRATEGIES WITHIN AUDITORY GROUPS BY SEX

LAMS				HAMS			
Male	Rank	Female	Rank	Male	Rank	Female	Rank
.80	16.5	.55	8	.90	19.5	.40	1
1.00	18.5	.55	8	.70	11.5	.85	17.5
.50	4.5	.55	8	.65	9.5	.75	14.5
.55	8	.70	13.5	.90	19.5	.75	14.5
1.00	18.5	.50	4.5	.70	11.5	.75	14.5
.70	13.5	.65	12	.55	5	.85	17.5
.45	2	.45	2	.75	14.5	.60	7.5
.55	8	.80	16.5	.65	9.5	.55	5
.45	2	.60	11	.55	5	.50	3
.75	15			.45	2	.60	7.5
	106.5		83.5		107.5		102.5

$$n_1 n_2 + \frac{n_1 (n_1 + 1)}{2} - R_1 = U$$

$9 \times 10 + 45 \quad 83.5 =$

$135 - 83.5 = 48.5 = U$

$U' = 90 - 48.5 = 41.5$

two-tail .05

critical value $U \leq 20$

$$U = n_1 n_2 + \frac{n_1 (n_1 + 1)}{2} - R_1$$

$= 100 + 55 - 107.5 = 47.5$

For a two-tail test when α is .05 the U critical value is $U \leq 23$

TABLE 19

MANN-WHITNEY U TEST OF DIFFERENCE IN SUMS OF RANKS ASSIGNED TO STABLE-STATE STRATEGIES OF HAMS VS. LAMS

Stable-State Strategies			
HAMS	Rank	LAMS	Rank
.90	36.5	.80	32.5
.70	24.5	1.00	38.5
.65	21.0	.50	7.0
.90	36.5	.55	12.5
.70	24.5	1.00	38.5
.55	12.5	.70	24.5
.75	29.0	.45	3.5
.65	21.0	.55	12.5
.55	12.5	.45	3.5
.45	3.5	.75	29.0
.40	1.0	.55	12.5
.85	34.5	.55	12.5
.75	29.0	.55	12.5
.75	29.0	.70	24.5
.75	29.0	.50	7.0
.85	34.5	.65	21.0
.60	18.0	.45	3.5
.55	12.5	.80	31.5
.50	7.0	.60	18.0
.60	18.0		
Total	434.0		346.0

$$U = n_1 n_2 + \frac{n_1 (n_1 + 1)}{2} - R_1$$

$$= 380 + \frac{380}{2} - 434$$

$$= 570 - 346 = 224$$

$$U = 380 - 224 = 156$$

With $\alpha = .05$ ($n_1 = 19$, $n_2 = 20$) Critical U for one-tailed test is $U \leq 130$

TABLE 20

KOLMOGOROV-SMIRNOV TEST FOR DIFFERENCES IN CUMULATIVE FREQUENCY OF PROPORTION OF ERRORS TO STABLE-STATE (p) FOR MALES VS. FEMALES WITHIN AUDITORY GROUPS

LAMS (p) Male (N=10)	LAMS (p) Female (N=10)	Proportion Interval	LAMS Male		LAMS Female		HAMS Male		HAMS Female	
.522	.456	.321-.320		0		0		0	X	1
.400	.467	.331-.340		0		0		0		1
.528	.489	.341-.350	X	1		0		0		1
.344	.478	.351-.360		1		0	X	1		1
.389	.459	.361-.370		1		0		1	XXXX	5
.383	.494	.371-.380		1		0		1		5
.544	.544	.381-.390	XX	3		0		1		5
.483	.428	.391-.400	X	4		0	X	2		5
.417	.450	.401-.410		4		0	X	3		5
.439	.478	.411-.420	X	5		0	XX	5		5
		.421-.430		5	X	1	X	6	XX	7
HAMS (p)		.431-.440	X	6		1		6		8
Male	Female	.441-.450		6	XX	3	X	7		8
(N=10)		.451-.460		6	X	4		7		8
.356	.494	.461-.470		6	X	5		7		8
.411	.367	.471-.480		6	XX	7		7		8
.500	.422	.481-.490	X	7	X	8		7		8
.417	.367	.491-.500		7	X	9	X	8	X	9
.506	.367	.501-.510		7		9	X	9		9
.428	.327	.511-.520		7		9		9		9
.406	.420	.521-.530	XX	9		9		9	X	10
.394	.439	.531-.540		9		9		9		10
.444	.367	.541-.550	X	10	X	10		9		10
.556	.528	.551-.560		10		10	X	10		10
			K_D Max. = 5				K_D Max. = 4			

Two-tailed test, N=10, Critical K_D Max. ≥ 7, where $\alpha = .05$

Mean error score for female LAMS was substituted for the score of the female S at the outset in order to meet the equal N requirement of the test.

TABLE 21

KOLMOGOROV-SMIRNOV TEST FOR DIFFERENCES IN CUMULATIVE FREQUENCY OF PROPORTIONS OF ERRORS TO STABLE-STATE (p) FOR LAMS VS. HAMS

Interval	Frequencies HAMS N=20	Frequencies LAMS N=20	Cumulated Frequencies HAMS	Cumulated Frequencies LAMS
.321 - .330	X		1	0
.331 - .340			1	0
.341 - .350		X	1	1
.351 - .360	X		2	1
.361 - .370	XXXX		6	1
.371 - .380			6	1
.381 - .390		XX	6	3
.391 - .400	X	X	7	4
.401 - .410	X		8	4
.411 - .420	XX		10	4
.421 - .430	XX	X	13	5
.431 - .440	X	XX	14	7
.441 - .450	X	XX	15	9
.451 - .460		X	15	10
.461 - .470		X	15	11
.471 - .480		XX	15	13
.481 - .490		XX	15	15
.491 - .500	XX	X	17	16
.501 - .510	X		18	16
.511 - .520			18	16
.521 - .530	X	XX	19	18
.531 - .540			19	18
.541 - .550		XX	19	20
.551 - .560	X		20	20
			K_D Max. = 8	

One-tailed test, N=20; Critical K_D Max ≥ 8, =.05.

* To meet equal N requirement for Kolmogorov-Smirnov test, the mean error score was substituted for the missing score of the female S eliminated from the LAMS group.

TABLE 22

KOLMOGOROV-SMIRNOV TEST FOR DIFFERENCES IN CUMULATIVE FREQUENCY OF PROPORTIONS OF ERRORS TO STABLE-STATE (p) FOR LAMS VS. HAMS WITHIN SEX GROUPS

Error Proportion Interval	Cumulative Frequencies: Males HAMS	Males LAMS	Females HAMS	Females LAMS*
.321 - .330	0	0	X 1	0
.331 - .340	0	0	1	0
.341 - .350	0	1 X	1	0
.351 - .360	X 1	1	1	0
.361 - .370	1	1	XXXX5	0
.371 - .380	1	1	5	0
.381 - .390	1	3 XX	5	0
.391 - .400	X 2	4 X	5	0
.401 - .410	X 3	4	5	0
.411 - .420	XX 5	5 X	5	0
.421 - .430	X 6	5	XX 7	1X
.431 - .440	6	6 X	X 8	1
.441 - .450	X 7	6	8	3XX
.451 - .460	7	6	8	4X
.461 - .470	7	6	8	5X
.471 - .480	7	6	8	7XX
.481 - .490	7	7 X	8	8X
.491 - .500	X 8	7	X 9	9X
.501 - .510	X 9	7	9	9
.511 - .520	9	7	9	9
.521 - .530	9	9 XX	X 10	9
.531 - .540	9	9	10	9
.541 - .550	9	10 X	10	10X
.551 - .560	X 10	10		
	K_D Max. = 2		K_D Max. = 7	

Where $\alpha = .05$, one-tailed test, N=10; Critical K_D Max ≥ 6

* The mean female LAMS score was substituted in place of the score of the female eliminated from the study.

**Significant at .01 level.

TABLE 23

MANN-WHITNEY U TEST OF DIFFERENCES IN THE SUM OF RANKS ASSIGNED TO STABLE-STATE STRATEGIES OF PAYOFF-LOSS MALES VS. FEMALES

Payoff-Loss LANS				
Males	Rank	Females	Rank	
.80	7.0	.95	18.0	
.65	3.0	.75	4.5	
.85	11.5	.95	18.0	
.55	2.0	.45	1.0	$U = n_1n_2 + \frac{n_1(n_1+1)}{2} - R_1$
.80	7.0	.80	7.0	
.85	11.5	.75	4.5	$= 100 + 55 - 111.5 = 43.5$
.95	18.0	.90	15.5	Critical U (two-tailed test)
.85	11.5	.85	11.5	where $\alpha = .05$, $n_1 = n_2 = 10$
.85	11.5	1.00	20.0	is $U \leq 23$.
.90	15.5	.85	11.5	
	98.5		111.5	

TABLE 24

MANN-WHITNEY U TEST FOR DIFFERENCES IN SUMS OF RANKS ASSIGNED TO STABLE-STATE STRATEGIES OF LAMS UNDER CONDITIONS OF PAYOFF-LOSS VS. NO-PAYOFF

LAMS Stable-State Strategies			
Po-Loss	Rank	No-Po	Rank
.80	23.0	.80	23.0
.65	14.5	1.00	38.0
.85	28.5	.50	5.5
.55	9.5	.55	9.5
.80	23.0	1.00	38.0
.85	28.5	.70	16.5
.95	35.0	.45	2.5
.85	28.5	.55	9.5
.85	28.5	.45	2.5
.90	32.5	.75	19.0
.95	35.0	.55	9.5
.75	19.0	.55	9.5
.95	35.0	.55	9.5
.45	2.5	.70	16.5
.80	23.0	.50	5.5
.75	19.0	.65	14.5
.90	32.5	.45	2.5
.85	28.5	.80	23.0
1.00	38.0	.60	13.0
.85	28.5		266.5
	512.5		

$$U = n_1n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$

$$= 380 + 190 - 266.5$$

$$= 570 - 266.5 = 303.5$$

$$U' = 380 - 303.5 = 76.5$$

Critical U (one-tailed test) where $\alpha = .05$ and $n_1 = 19$, $n_2 = 20$ is $U \leq 130$

* Significant at the .05, .01, and .001 levels.

TABLE 25

MANN-WHITNEY U TEST OF DIFFERENCES IN THE SUM OF RANKS ASSIGNED TO STABLE-STATE STRATEGIES OF THE PAYOFF-LOSS VS. NO-PAYOFF GROUPS BY SEX

Male LAMS				Female LAMS			
Payoff-Loss		No-Payoff		Payoff-Loss		No-Payoff	
SSS	Rank	SSS	Rank	SSS	Rank	SSS	Rank
.80	11.0	.80	11.0	.95	17.5	.55	5.0
.65	7.0	1.00	19.5	.75	10.5	.55	5.0
.85	14.5	.50	3.0	.95	17.5	.55	5.0
.55	5.0	.55	5.0	.45	1.5	.70	9.0
.80	11.0	1.00	19.5	.80	12.5	.50	3.0
.85	14.5	.70	8.0	.75	10.5	.65	8.0
.95	18.0	.45	1.5	.90	16.0	.45	1.5
.85	14.5	.55	5.0	.85	14.5	.80	12.5
.85	14.5	.45	1.5	1.00	19.0	.60	7.0
.90	17.0	.75	9.0	.85	14.5		
	127.0		83.0		134.0		

$$U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$

$= 155 - 127 = 28$

Critical U (one-tailed test) where $\alpha = .05$, $n_1 = n_2 = 10$ is $U \leq 27$

$U = 90 + 45 - 56 = 79$

$U' = 90 - 79 = 11$*

Critical U (one-tailed test where $\alpha = .05$ and $n_1 = 9$, $n_2 = 10$ is $U \leq 24$

* Significant beyond the .001 level.

TABLE 26

KOLMOGOROV-SMIRNOV TEST OF DIFFERENCES IN CUMULATIVE FREQUENCY OF PRE-STABLE-STATE PROPORTION OF ERRORS TO STABLE STATE FOR MALE VS. FEMALE LAMS WITHIN PAYOFF CONDITION

(Pairs)	ERROR SCORES Payoff-Loss Males (N=10)	Females
1	83	70
2	85	79
3	64	79
4	78	94
5	87	74
6	73	69
7	81	66
8	77	69
9	71	51
10	69	74
	No-Payoff Males N=10	**Females* N=10**
1	94	82
2	72	84
3	79	88
4	95	86
5	62	81
6	70	89
7	69	98
8	98	77
9	87	81
10	75	85*

CUMULATIVE ERROR Proportion Interval	CUMULATIVE FREQUENCIES Payoff-Loss Male	Payoff-Loss Female	No-Payoff Male	No-Payoff Female
.281 - .290		X 1		
		1		
.301 - .310		1		
		1		
.321 - .330		1		
		1		
.341 - .350		1	X 1	
	X 1	1	1	
.361 - .370	1	X 2	1	
	1	2	1	
.381 - .390	X 2	XXX 5	XX 3	
	X 3	X 6	X 4	
.401 - .410	X 4	6	4	
	4	X 7	X 5	0
.421 - .430	X 5	7	5	X 1
	X 6	XX 9	X 6	1
.441 - .450	X 7	9	6	XX 3
	7	9	6	X 4
.461 - .470	X 8	9	6	X 5
	X 9	9	6	XX 7
.481 - .490	X 10	9	X 7	X 8
	10	9	7	X 9
.501 - .510	10	9	7	9
	10	9	7	9
.521 - .530	10	X 10	XX 9	9
	10	10	9	9
.541 - .550	10	10	X 10	X 10
	K_D Max. = 3		K_D Max. = 5	

Critical K_D (two-tailed) $\alpha = .05$, N=10,

is $K_D \geq 6$

*In order to accommodate the equal N requirement of the test, the mean error score ($\bar{X}$ = 86.00, p = .478) was substituted for the score of the No-payoff female who was eliminated from all tests.

TABLE 27

KOLMOGOROV-SMIRNOV TEST OF DIFFERENCES IN TOTAL PROPORTION OF ERRORS TO STABLE-STATE FOR LAMS UNDER PAYOFF-LOSS VS. NO-PAYOFF CONDITIONS

Interval	Cumulative Frequencies				
	Payoff-Loss		K_D Max	No-Payoff*	
.281 - .290	X	1		0	
		1		0	
.301 - .310		1		0	
		1		0	
.321 - .330		1		0	
		1		0	
.341 - .350		1		1	X
	X	2		1	
.361 - .370	X	3		1	
		3		1	
.381 - .390	XXXX	7		3	XX
	XX	9		4	X
.401 - .410	X	10		4	
	X	11		5	X
.421 - .430	X	12		6	X
	XXX	15	8**	7	X
.441 - .450	X	16		9	XX
		16		10	X
.461 - .470	X	17		11	X
	X	18		13	XX
.481 - .490	X	19		15	XX
		19		16	X
.501 - .510		19		16	
		19		16	
.521 - .530	X	20		18	XX
		20		18	
.541 - .550		20		20	XX

K_D max (one-tailed test) $\alpha = .05$, N=20 $K_D \geq 8$ is critical.

* In order to accommodate the equal N requirement of the test the mean error score for no-payoff female LAMS was substituted for the female eliminated from that group at the outset.

** Significant at the .05 level.

TABLE 28

KOLMOGOROV-SMIRNOV TEST OF DIFFERENCES IN CUMULATIVE FREQUENCY OF PRE-STABLE-STATE ERRORS FOR MALE AND FEMALE LAMS UNDER PAYOFF-LOSS VS. NO-PAYOFF CONDITIONS

	FEMALE LAMS (N = 10)*				MALE LAMS (N = 10)			
	Po-Loss		No-Po		Po-Loss		No-Po	
Interval	(F)	Cum(F)	Cum(F)	(F)	(F)	Cum(F)	Cum(F)	(F)
.281-.290	X	1						
		1						
.301-.310		1						
		1						
.321-.330		1						
		1						
.341-.350		1				0	1	X
		1			X	1	1	
.361-.370	X	2				1	1	
		2				1	1	
.381-.390	XXX	5			X	2	3	XX
	X	6			X	3	4	X
.401-.410		6			X	4	4	
	X	7				4	5	X
.421-.430		7	1	X	X	5	5	
	XX	9	1		X	6	6	X
.441-.450		9	3	XX	X	7	6	
		9	4	X		7	6	
.461-.470		9	5	X	X	8	6	
		9	7	XX	X	9	6	
.481-.490		9	8	X	X	10	7	X
		9	9	X		10	7	
.501-.510		9	9			10	7	
		9	9			10	7	
.521-.530	X	10	9			10	9	XX
		10	9			10	9	
.541-.550		10	10	X		10	10	X
		K_D Max. = 8				K_D Max. = 3		

K_D Max. (one-tailed test) α = .05, N=10 $K_D \geq 6$ is critical.

*In order to satisfy the equal N requirement of the test the mean error score, ($\bar{X}$ = 86, p = .478), of the no-payoff female LAMS was substituted for the score of the S eliminated from the study at the outset.

**Significant at the .01 level.

TABLE 29

MANN-WHITNEY U TEST FOR DIFFERENCES IN SUMS OF RANKS ASSIGNED TO STABLE-STATE STRATEGIES OF LAMS UNDER CONDITIONS OF PAYOFF-LOSS VS. HAMS UNDER NO-PAYOFF

Po-Loss LAMS		No-Po HAMS	
SSS	Rank	SSS	Rank
.80	23.5	.90	34.5
.65	12.0	.70	14.5
.85	29.0	.65	12.0
.55	6.5	.90	34.5
.80	23.5	.70	14.5
.85	29.0	.55	6.5
.95	38.0	.75	18.5
.85	29.0	.65	12.0
.85	29.0	.55	6.5
.90	34.5	.45	2.5
.95	38.0	.40	[illegible].0
.75	18.5	.80	23.5
.95	38.0	.75	18.5
.45	2.5	.75	18.5
.80	23.5	.75	18.5
.75	18.5	.85	29.0
.90	34.5	.60	9.5
.85	29.0	.55	6.5
1.00	40.0	.50	4.0
.85	29.0	.60	9.5
	525.5		294.5

$$U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$

$$= 400 + \frac{420}{2} - 525.5$$

$$= 610 - 525.5 = 84.5^*$$

Critical U value when

$\alpha = .05$ (one-tailed test)

$n_1 = n_2 = 20$ is $U \leq 138$.

* Significant at .001 level.